Air & Space

National Air & Space Museum
Smithsonian Institution

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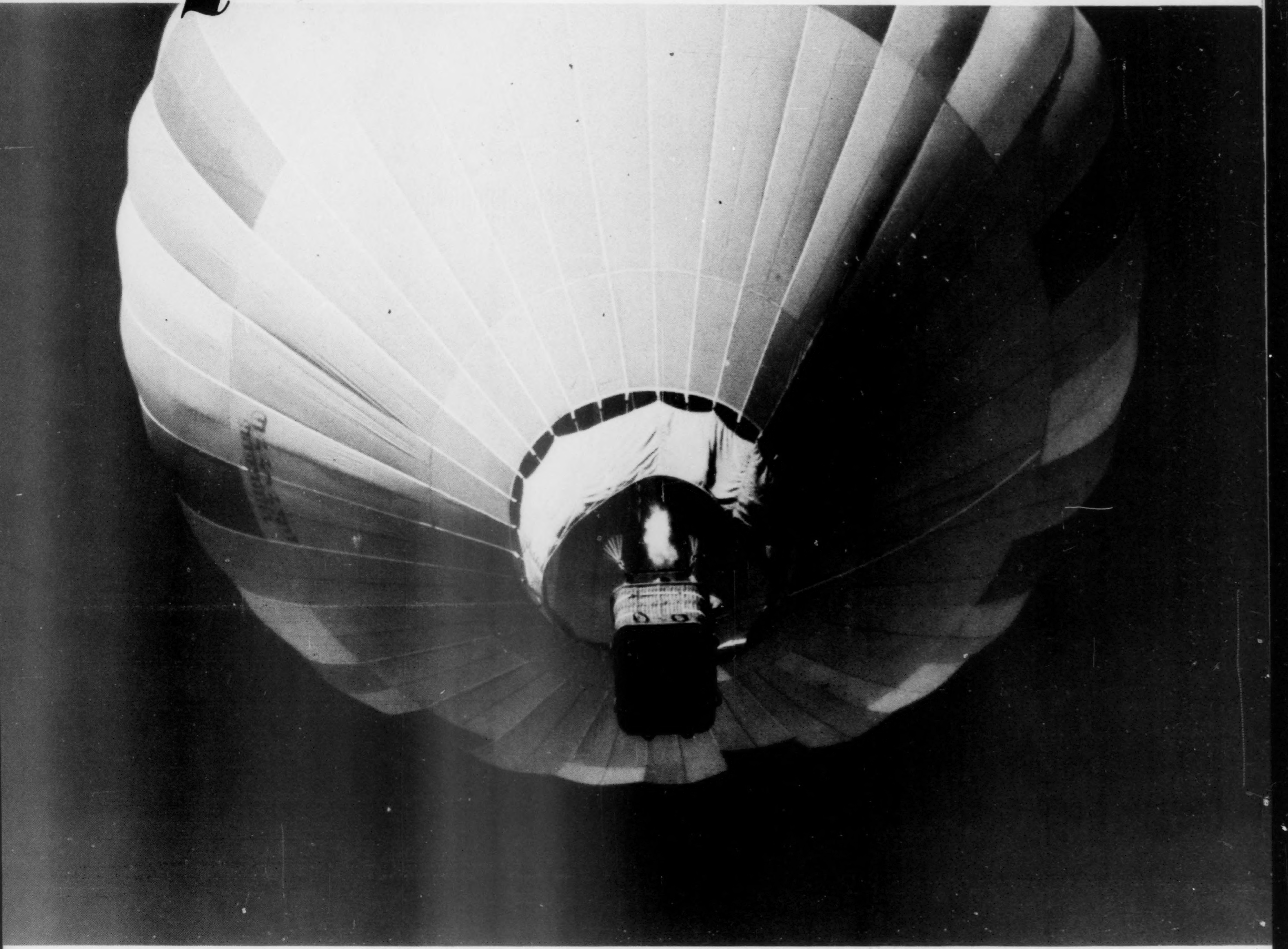


196 Years of Ballooning

The tension was unbearable for the waiting throngs, on November 21, 1783, when two Frenchmen in satins and velvet stepped into the gallery of an elegant balloon. Lifted by hot air, they floated aloft—the first mortals ever to risk their lives in unknown regions overhead. The basic design and operation of balloons were mastered in the early days and have changed little since. The euphoria of separation from the mundane, intimacy with the winds, the unearthly quiet (when the burner isn't blasting)—these sensations are luring numbers of people into the revived sport of ballooning. While not inexpensive, a hot air balloon is more affordable than a helium gas balloon. Flying either kind is an art of responsiveness to the atmosphere in its variable and invisible moods. The only specific control is up or down. One is never certain about the landing point. For that reason, the historic tradition of breaking out champagne for one's surprised hosts, on landing, helps to make new friends. (More, Pages 3, 4, 5)

Briefing

Melvin B. Zisfein
Deputy Director, NASM

A major thrust of this issue of *Air & Space* is ballooning, which suits me fine. For many years I have been fascinated by ballooning and balloonists, most of whom are among the most interesting people one can meet. I have only been up in a hot air balloon on a couple of tethered flights, never in a free balloon of either the hot air or gas variety. It is definitely one of my unfulfilled ambitions.

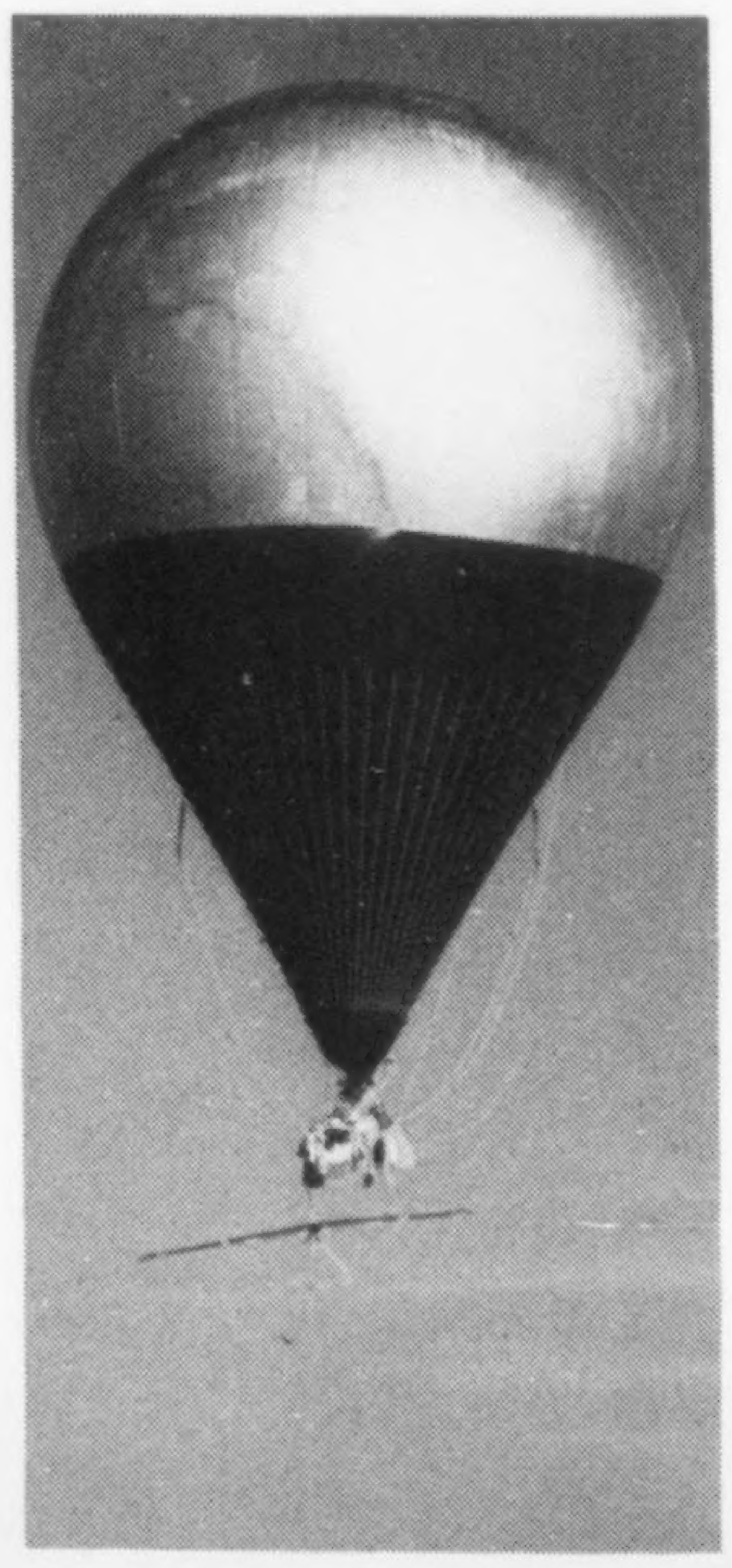
But golly, have I met balloonists. Several years ago I met a group which, among other things, is concerned with staging the yearly mass hot air balloon events near Albuquerque, New Mexico. Later they said they were considering a transatlantic flight. Consequently, last August, when I heard that a team of balloonists from New Mexico was in the air attempting the first transatlantic crossing, I wasn't very surprised. I began to be surprised when I learned from the media that their names—Maxie Anderson, Ben Abruzzo and Larry Newman—were different from the group that I knew, and that they were in a balloon that they called *Double Eagle II*. Yet there they were, crossing the Atlantic Ocean, nearing England and proceeding well.

We must now digress. Paul Garber, currently 79 years young, is our Historian Emeritus. He has been an employee of the Smithsonian since 1920. During Lindbergh's famous transatlantic *Spirit of St. Louis* flight, a 27-year-old Paul Garber approached the Secretary of the Smithsonian with the proposition of sending a cable to LeBourget Field requesting the *Spirit of St. Louis* from Lindbergh while he was still in the air. The Secretary approved, the message was sent, and Lindbergh received it when he landed. He was agreeable, and that is how we got the *Spirit of St. Louis*.

Why not emulate the *Spirit of St. Louis* maneuver and get the soon-to-be-triumphant *Double Eagle II*? At about 11:30 p.m. I phoned the head of our Aeronautics Department and requested that they cable, in my name, the Air Attaches of the American embassies in London and Paris, requesting that should the *Double Eagle II* land in either of those countries, would they please request the gondola, balloon, and all artifacts for the National Air and Space Museum.

We got the *Double Eagle II*. However, it wasn't until several months later that I learned one of the most interesting details of the acquisition. When the crew of the balloon visited Washington, they were entertained at the White House, the National Press Club and the Smithsonian. During their speeches, I found out that while they were floating high above the English Channel headed for France, their normal radio channels were jammed with congratulatory messages from nearby aircraft, ships and ground stations. However, my message requesting the *Double Eagle II* was communicated to the crew from the American Embassy in Paris via an emergency radio channel that was completely clear. Their response (not having yet landed) was a mixture of incredulity and humor, and their agreement was instantaneous.

Maybe someday I will get a balloon ride!



NOEL W. HINNERS
Director
National Air and Space Museum

The appointment of Dr. Hinners to succeed astronaut Michael Collins as director was announced by S. Dillon Ripley, Secretary of the Smithsonian Institution, and became effective in April. Mr. Collins was named Under Secretary of the Smithsonian in April, 1978.

Dr. Hinners has been Associate Administrator for Space Science at the National Aeronautics and Space Administration (NASA) since 1974, formulating programs in astrophysics, solar-terrestrial relations, lunar and planetary exploration and the life sciences, including such missions as Viking, Voyager, Pioneer, High Energy Astronomy Observatory, and the Space Telescope.

While still in high school he earned a private pilot's license. His B.S. came from Rutgers University, 1958; his M.S. from California Institute of Technology, 1960; his Ph.D. in geochemistry and geology from Princeton University, 1963. While head of the Lunar Exploration Department at Bellcomm, Inc., he received the NASA Exceptional Scientific Achievement Award in 1971, and joined NASA the following year.

Dr. David Challinor, Smithsonian Assistant Secretary for Science, described Dr. Hinners as "eminently qualified" to head NASM, and said, "We look forward to the impetus his presence will give to our efforts to strengthen the Museum's research and educational programs . . ."

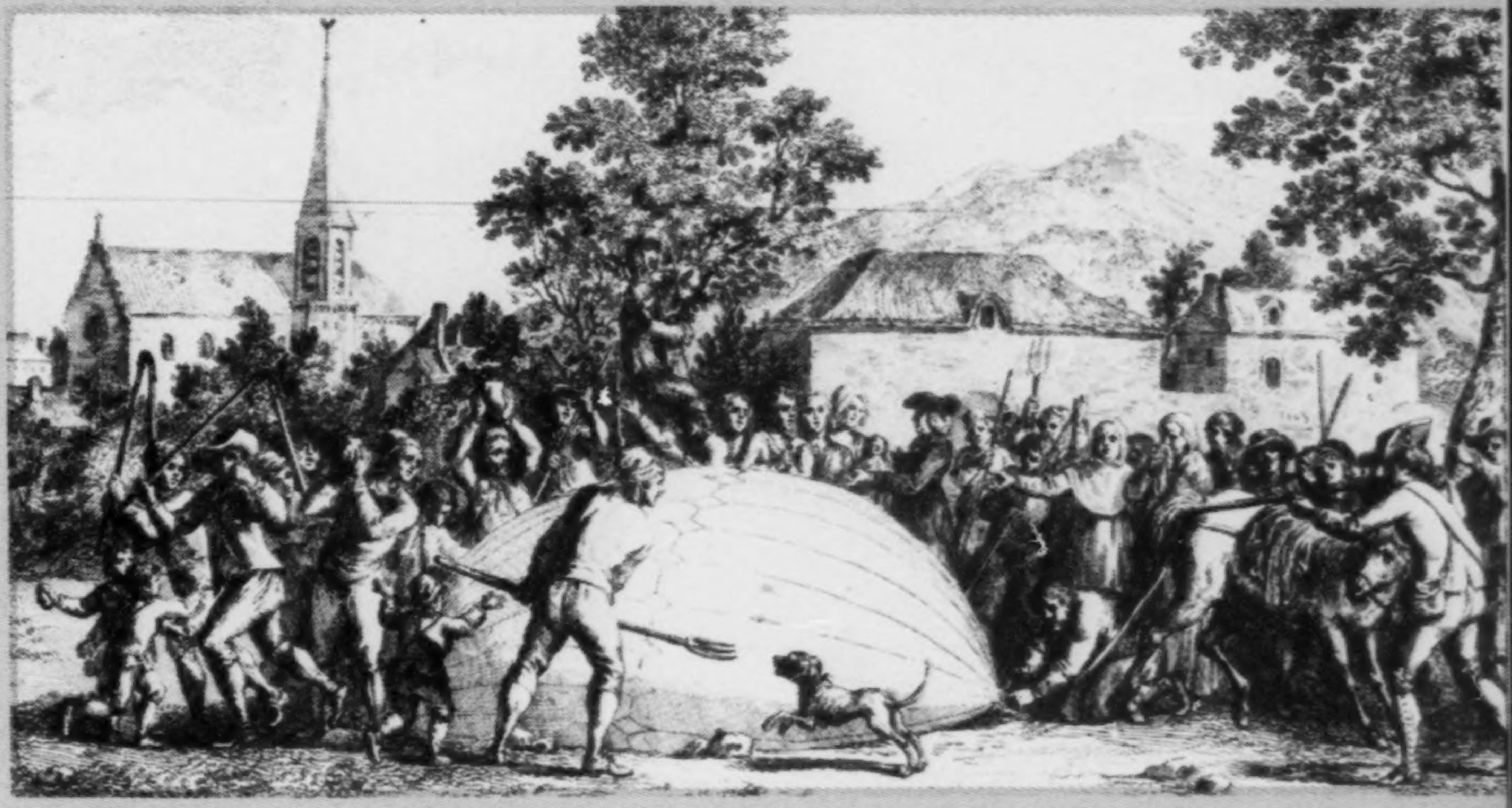
Mr. Zisfein resumes his post as NASM's Deputy Director.

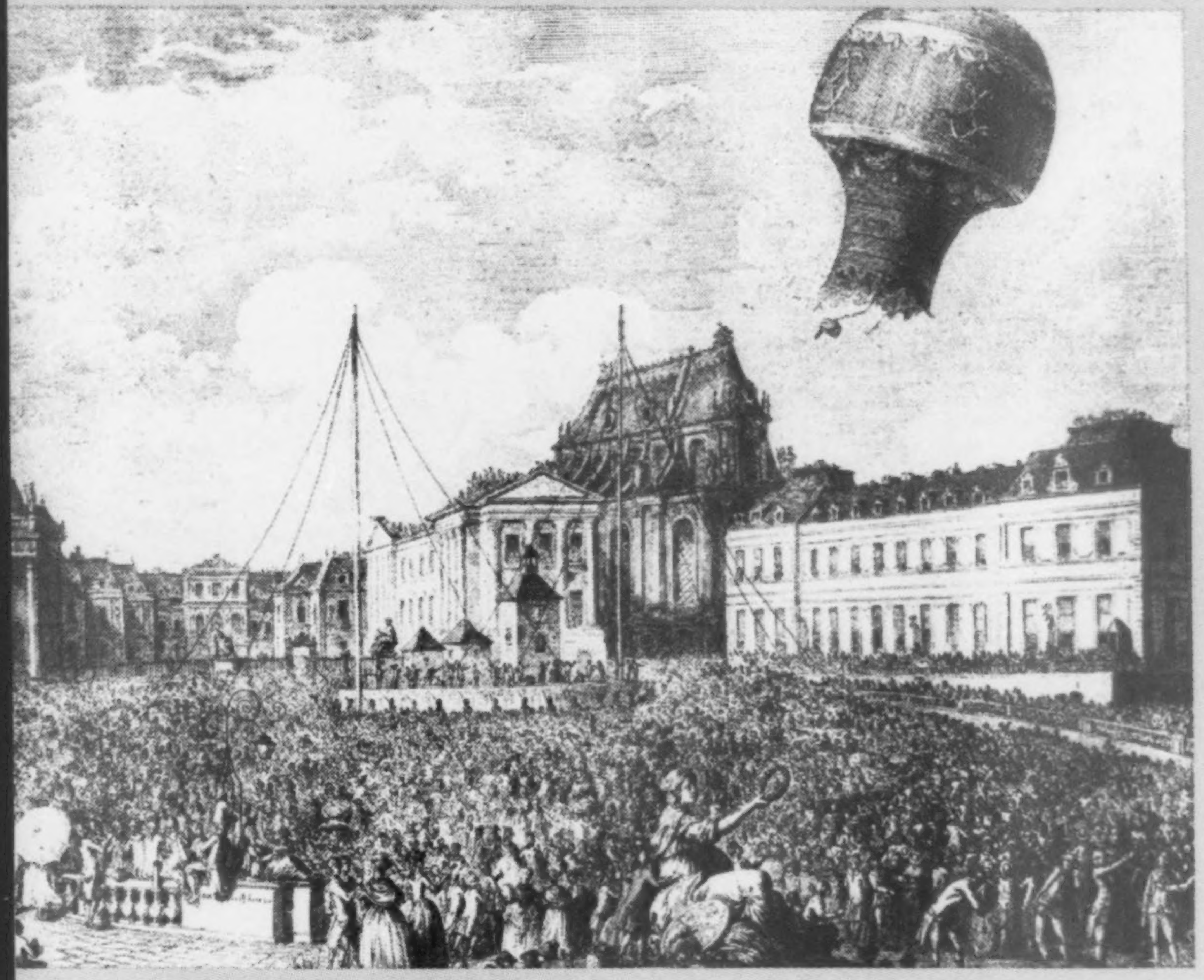
At NASM:

Summer visitors will find the Museum open seven days a week, 10 a.m. to 9 p.m. through September 3. At the time of the 10th anniversary of Apollo 11, July 16-24, many special events are scheduled. A commemorative book will be available then: *Ten Years Since Tranquility: Reflections upon Apollo 11*. NASM curators Richard P. Hallion, editor, Tom D. Crouch, assistant editor. Ten essays, 221 pages, 60 photographs, bibliography, index. Smithsonian Press, P.O. Box 1579, Washington, DC 20013, $20, or $7.95 paperback.

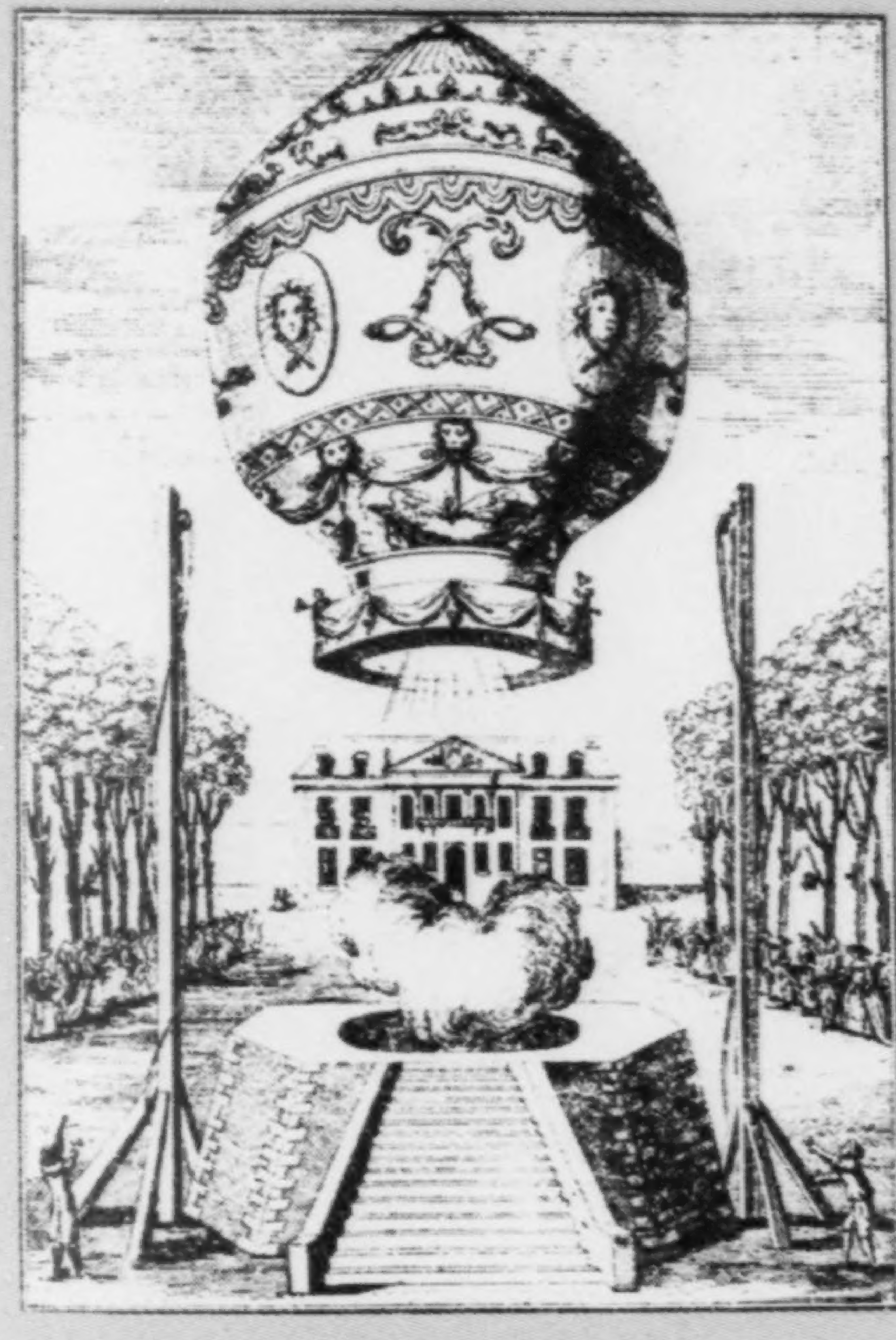
The Invention of Lighter-than-air Craft in France--in One Astonishing Year, 1783

First, the Montgolfier brothers, who owned a paper mill and sought diversification, built a large bag of linen, lined with paper, 10.7 meters in diameter. A fire under its launching platform sent into the bag clouds of smoke, once thought the cause of lift. The balloon soared elegantly and came to land two kilometers distant. This was in the provinces, at Annonay, near Lyons, June 4, 1783. The news enthralled the French. A public subscription provided funds wherewith physicist J. A. C. Charles constructed an envelope of silk taffeta treated with an elastic gum, four meters in diameter, filled with "inflammable air"—hydrogen. On August 27, 1783, 300,000 Parisians marveled at the ascent, among them the first U.S. minister to France, Benjamin Franklin. In 45 minutes, "Globe" drifted 24 kilometers, beyond the city. Farmers thought it the skin of some monstrous demon from the sky, and attacked with stones, pitchforks and muskets, then hitched it to a terrified horse that dragged it across the fields until it was assuredly dead. (Old print of the scene, right.)

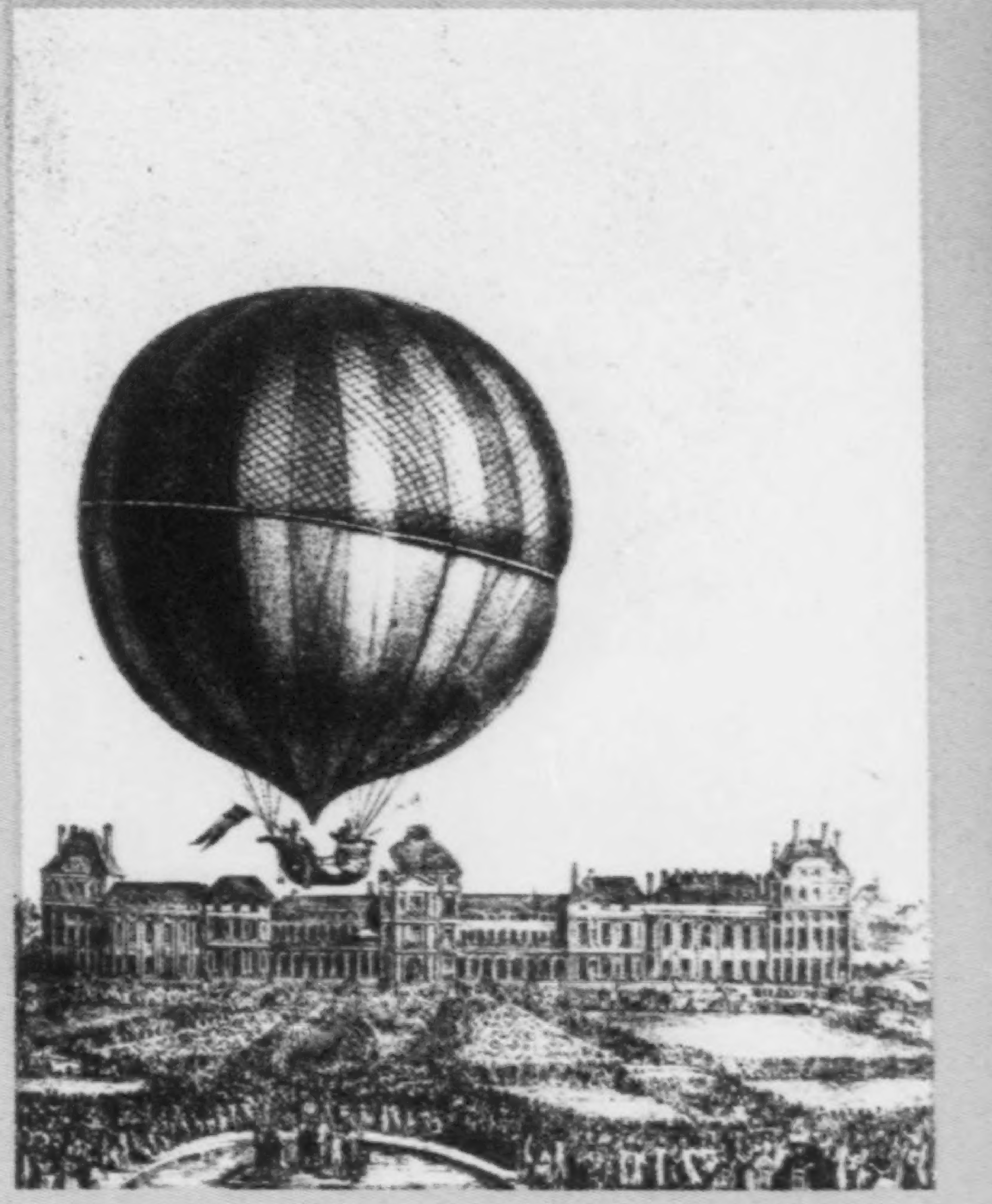




All in 1783: Sept. 19, first ascent of animals, in basket.

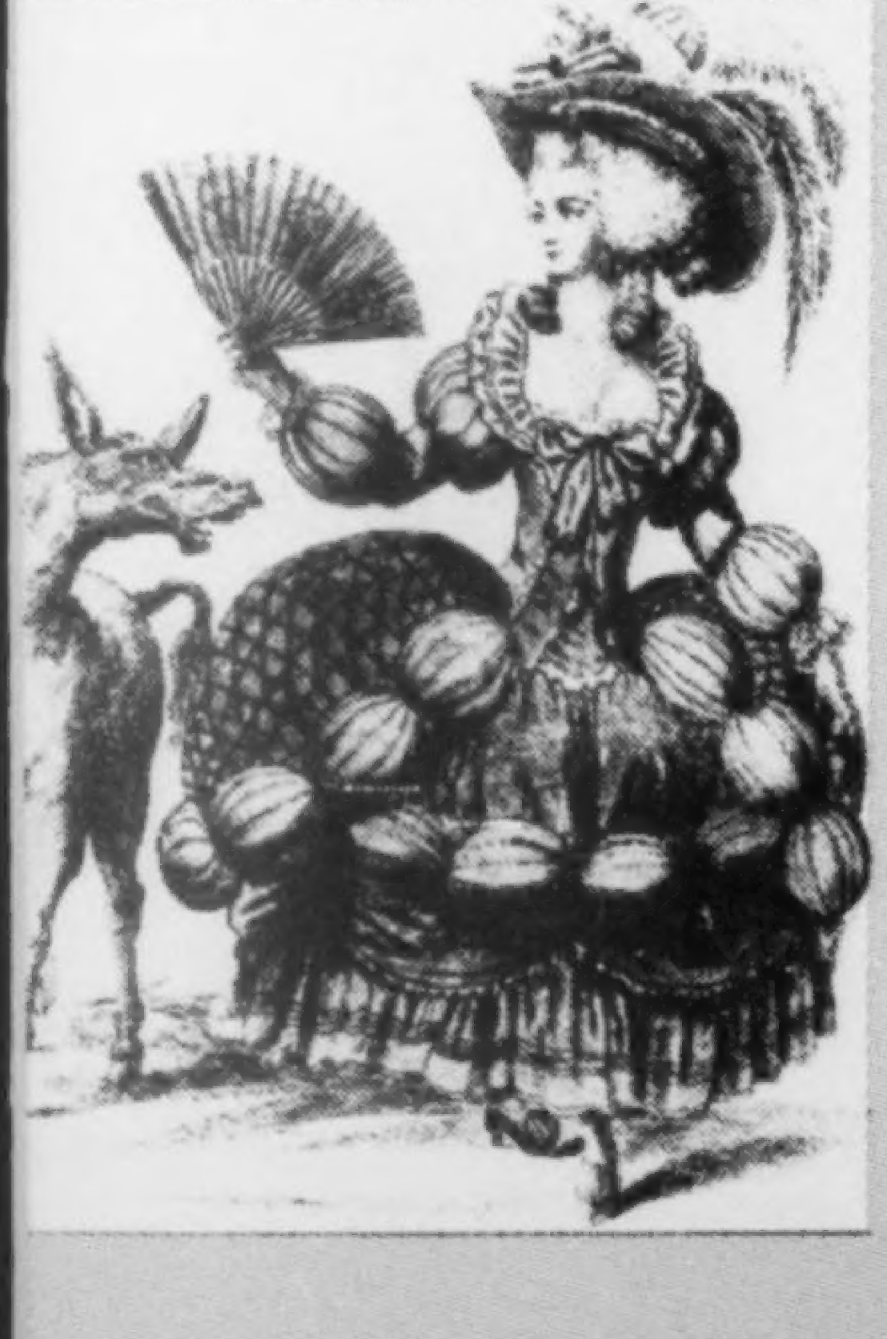


Nov. 21, first manned ascent.



Dec. 1, first manned hydrogen balloon.

The sequence of events which led to the first human venture into the atmosphere had a precise parallel 174 years later, in events that prepared for the first manned spaceflight.

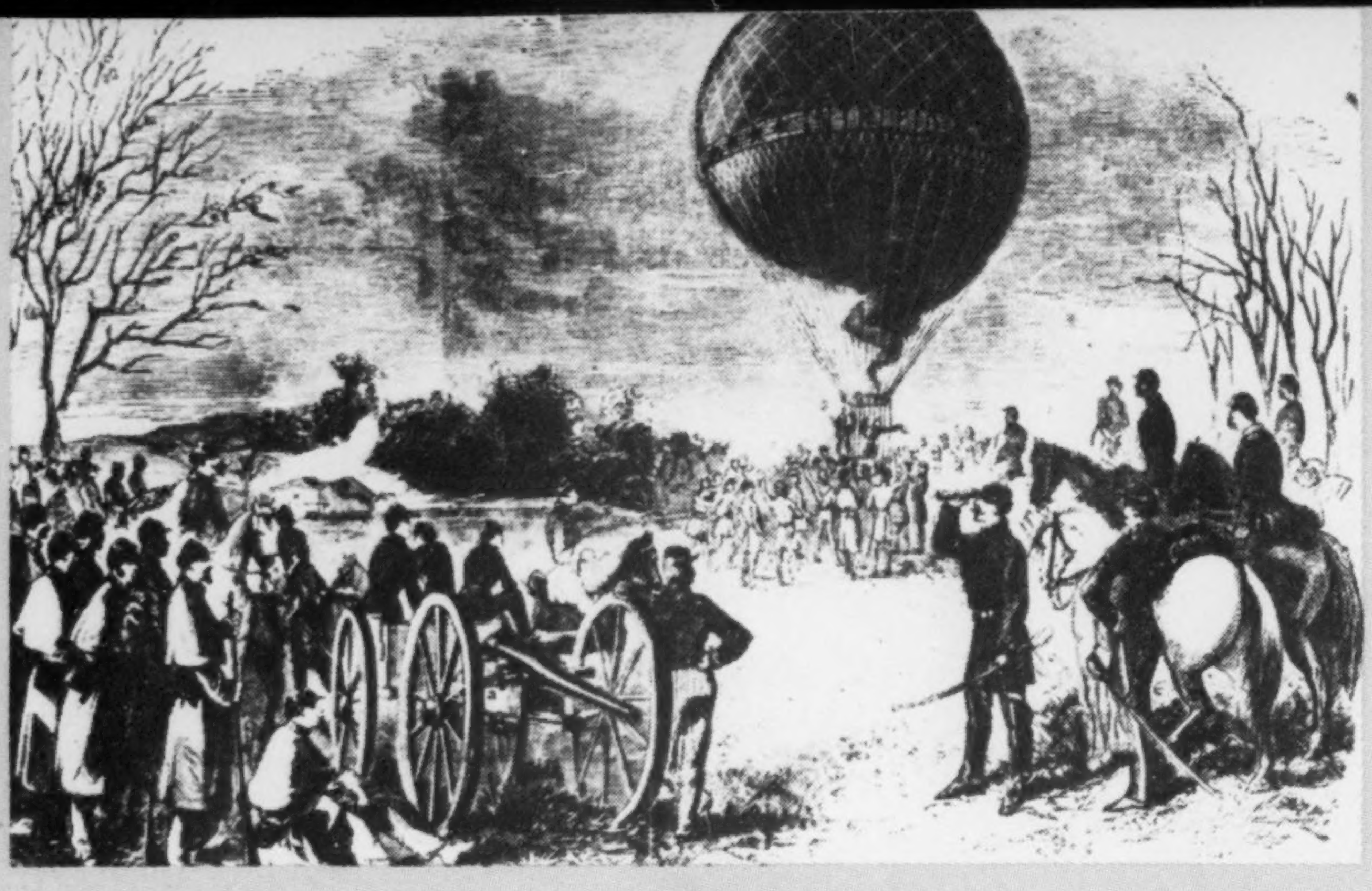


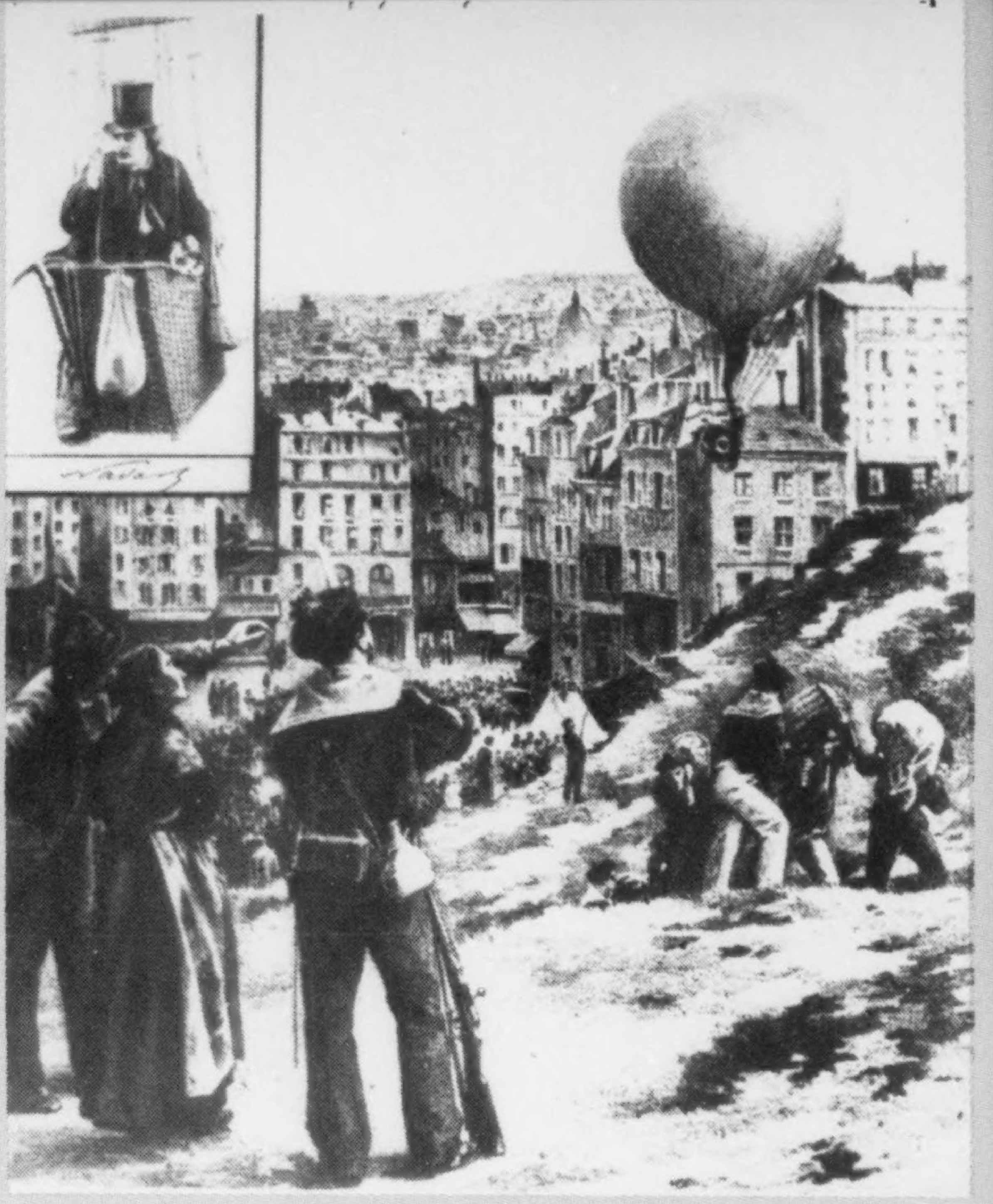
In 1783, the atmosphere was more of an unknown than was space in 1957. In both cases, the vehicles had to prove themselves first. Then, should man dare to ascend? Could men live and breathe in the sky? In 1783, King Louis XVI decreed that animals must be sent first. On September 19, 1783, throngs at Versailles watched as a Montgolfier balloon, filled with hot air, carried aloft a covered basket containing a sheep, a duck and a rooster. The animals did indeed survive the eight-minute trip, to some 450 meters altitude, over a distance of three kilometers.

In the crowd which chased the balloon to its landing, Joseph Montgolfier met a young scientist, Pilâtre de Rozier, who later managed to make himself commander of the first manned ascension. The historic date: November 21, 1783. Rozier and the Marquis d'Arlandes stood in the circular gallery of a "Montgolfière." This time the balloon would sustain its lift by taking along a source of hot air, a fire in a central grate.

Parisians were ecstatic as the elegant craft soared—and dipped, when d'Arlandes became so entranced with the vistas that he forgot to keep throwing straw on the fire.

Eleven days later, Prof. Jacques Alexandre César Charles and his balloon maker, M. N. Robert, flew farther in Charles' hydrogen-filled globe, a type immediately called a "Charlière" and little changed even today. Europe and soon the U.S. were swept by a "balloon mania" which lasted for decades. Balloon motifs ornamented homefurnishings. Women's fashions provoked caricature (old sketch, left). History has no parallel until the outpouring of emotion for Lindbergh and for the first Moon-landing.





Left, a gas balloon used for reconnaissance during the U.S. Civil War. Right, one of 64 postal service balloons lofted out of Paris during the 1870 Prussian siege.

Literary works, like homefurnishings and fashion, responded to the popular delight in ballooning. One of the best tales is Jules Verne's *Five Weeks in a Balloon,* published in 1863. His fictional explorers float over Africa and meet engaging adventures.

Scientists began to use balloons in 1803. By mid-century, they were competing for altitude records and data.

Explorers took balloons throughout the world. In 1897, three arctic researchers lifted off for the North Pole, and disappeared; 33 years later, sailors happened upon their remains and records of the storms and icing which had forced the balloon down.

In 1931, Auguste Piccard developed sealed gondolas in which manned ascents could reach greater heights than ever. The present altitude record of 37 650 meters was set in 1966.

The unmanned balloon carrying scientific instruments—like unmanned, instrumented spacecraft—can go far, where it is impracticable, too costly or unnecessary to send human observers. Radio-controlled polyethylene balloons, as shown below, can rise as high as 50 kilometers and return their instrument payloads by parachute.

Military forces used balloons for reconnaissance when an observer a few hundred feet overhead was able to see the entire arena of a battle. In 1793 the French organized the first "air force," a balloon corps called *Les Aérostatiers.* Today, it is hard to imagine the psychological value of early balloons. When Austrian soldiers saw a reconnaissance balloon rise from inside a beleaguered French town, they believed they were dealing with sorcerers.

During the U.S. Civil War, the Secretary of the Smithsonian Institution, Joseph Henry, supported Thaddeus Lowe's successful effort to have a reconnaissance balloon corps authorized by President Abraham Lincoln. At first, military balloons had to be inflated at the Washington Gas plant and then hauled to the battlefield tied to wagons or walked along with soldiers holding tethering lines . . . and tangling with trees all the way. Soon portable hydrogen gas generators were designed, at the Smithsonian, and put into production. Early in the war, reconnaissance balloonists began sending down their reports by telegraphy, via a wire wrapped onto the tether rope.

During the Franco-Prussian War and the siege of Paris (1870-1871), balloons provided the world's first airlift. Production lines set up in railway stations turned out dozens of cheap, varnished calico envelopes for hydrogen-filled balloons. Sixty-four of them wafted out of the city above the blockade; only five were captured. This *Balloon Poste* carried 100 passengers, two and a half million letters, and 400 homing pigeons, some of which made their way back with answers, usually on microfilm.

A little known story is that during World War II, the Japanese made 10 000 bomb-carrying paper balloons and launched 9000 on the high jetstream which always blows to the east. Some 1000 of them reached the western shores of North America but did little damage.

In order to keep up with technology, the U.S. Navy, in 1961, commissioned Paul E. (Ed) Yost to think about ballooning. His innovations and adaptations, such as synthetic fabrics, propane burners, and certain special hardware —have brought a revival of hot air ballooning for sport.

Books of any vintage are useful, and often delightful. As would be expected, there is a wealth of literature in French —lively reading for students of French.

Readings

The Romance of Ballooning: The Story of the Early Aeronauts, 203 pp., illus., biblio. (most in French). Viking, New York, 1971.

The Book of Balloons, Erik Norgaard, 198 pp., illus. Crown, New York, 1970.

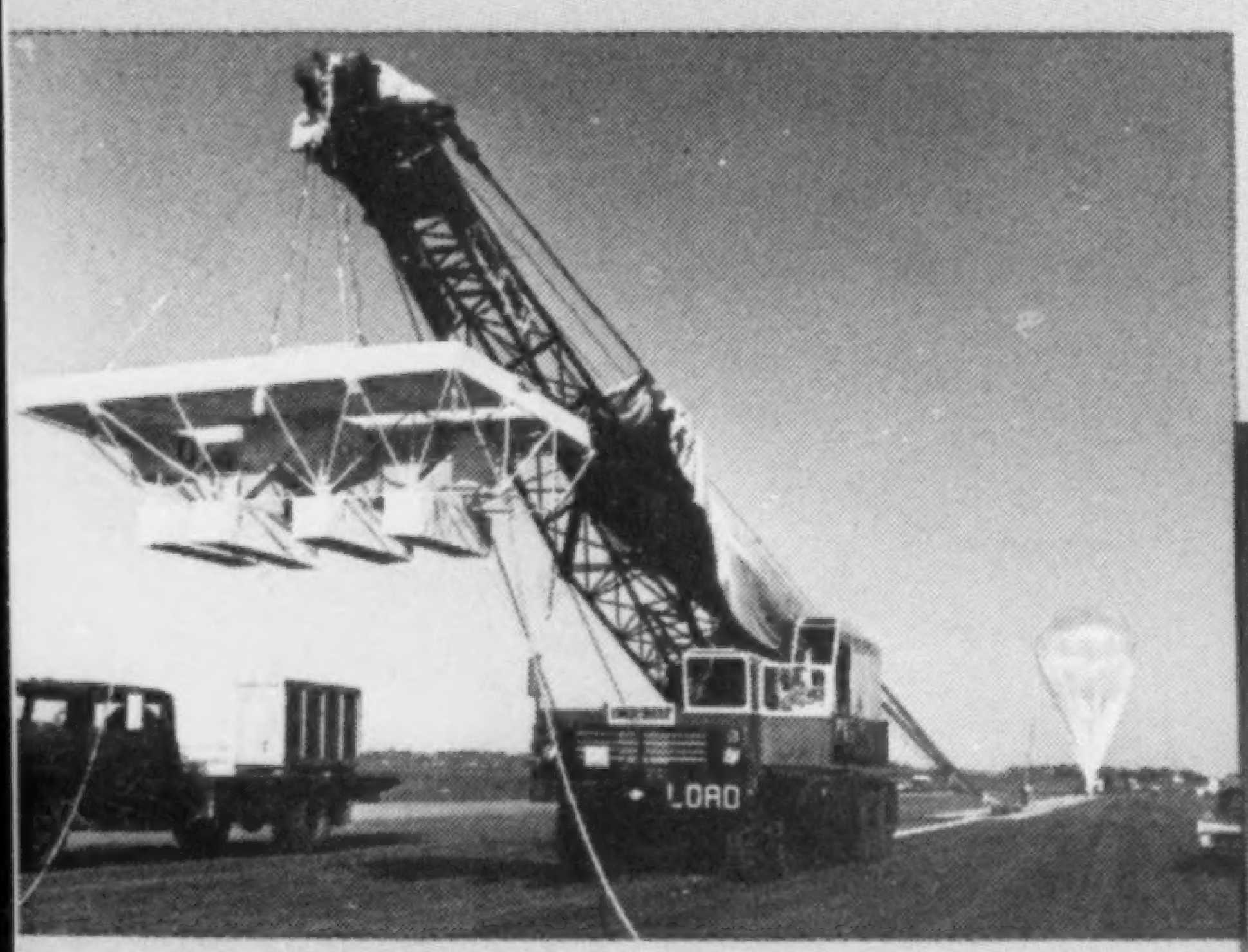
Aeronautics, Lighter-than-Air Craft, Science Museum, London. Paperback, 112 pp., illus., index, 1950.

L'Histoire de l'Aéronautique, Charles Dollfus, Henri Bouche. 569 pp., illus., 1942.

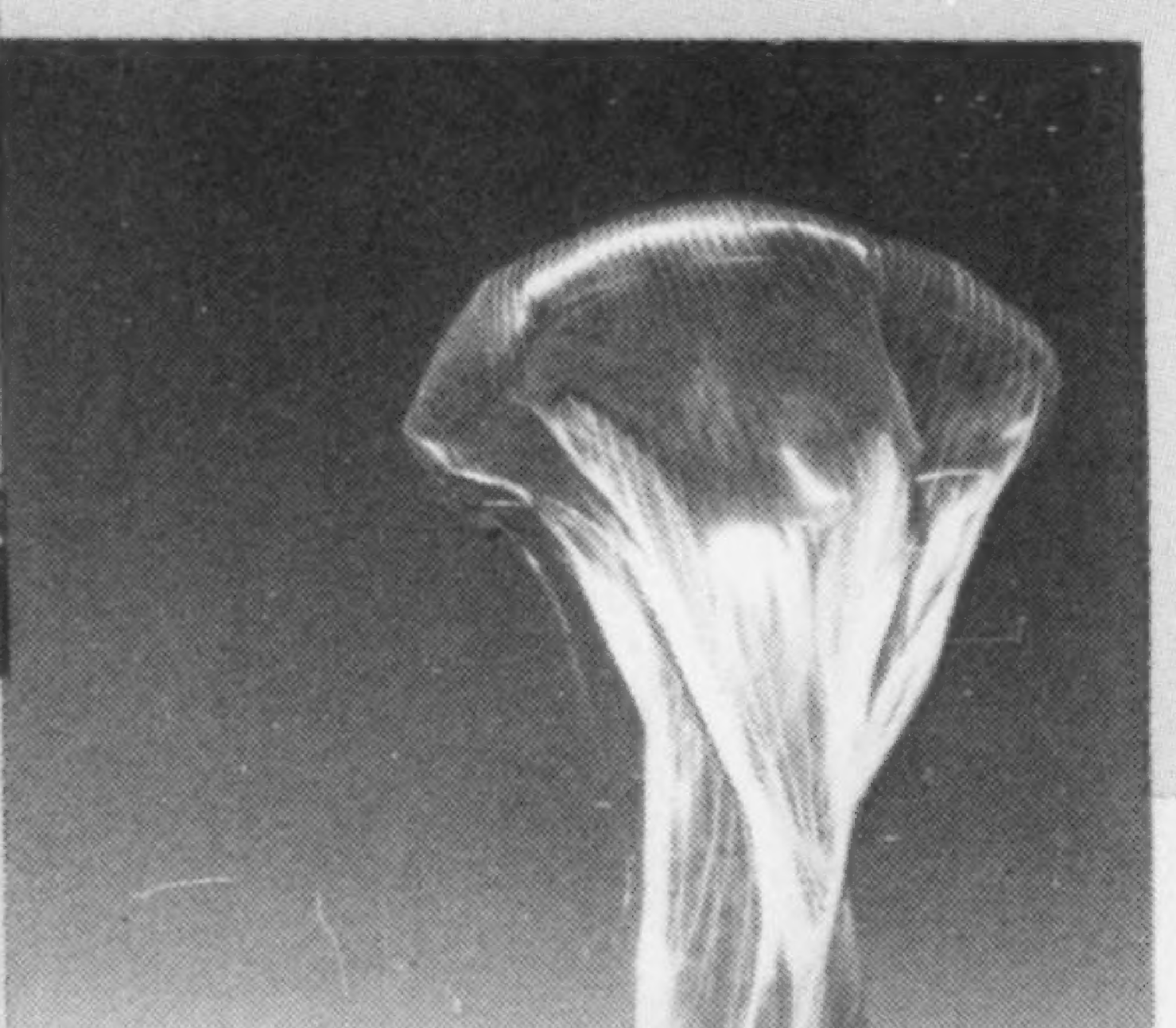
Japan's World War II Balloon Bomb Attacks on North America, Robert C. Mikesh. Paperback, 85 pp., illus., biblio., index. Smithsonian Press, 1973. Government Printing Office, Washington, DC 20402, Stock No. SN047-005-00009-4, $2.75.

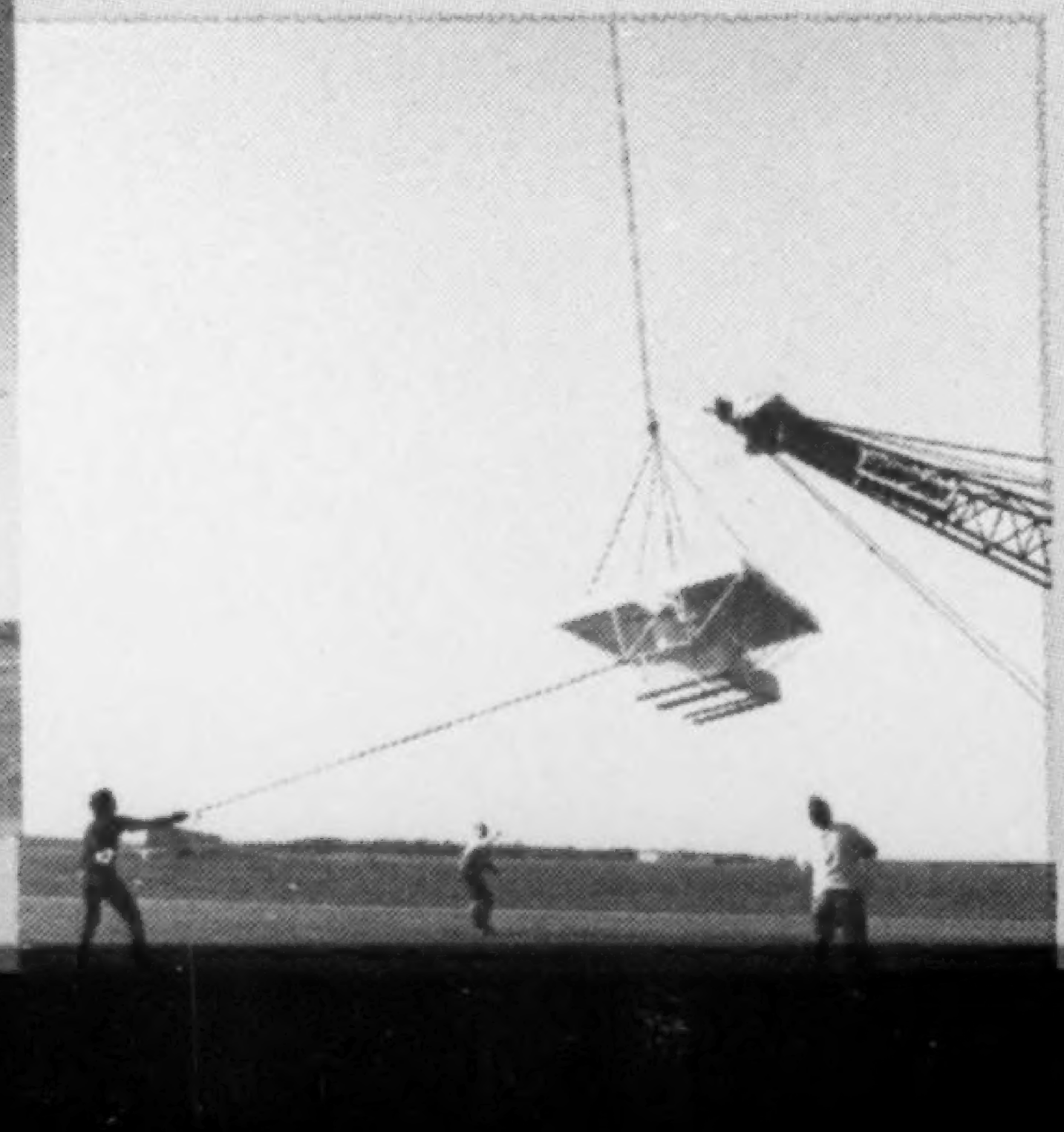
The Balloon Book, Paul Fillingham. 226 pp., illus., biblio., index. McKay, New York, 1977.

LIFT-OFF: UNMANNED BALLOON FOR SCIENTIFIC RESEARCH



Payload (above) includes large sheets of photographic emulsion to be exposed by passage of cosmic ray particles; a ballast hopper; telemetry; radio controls; impact-absorbing crash pads (the four boxes).





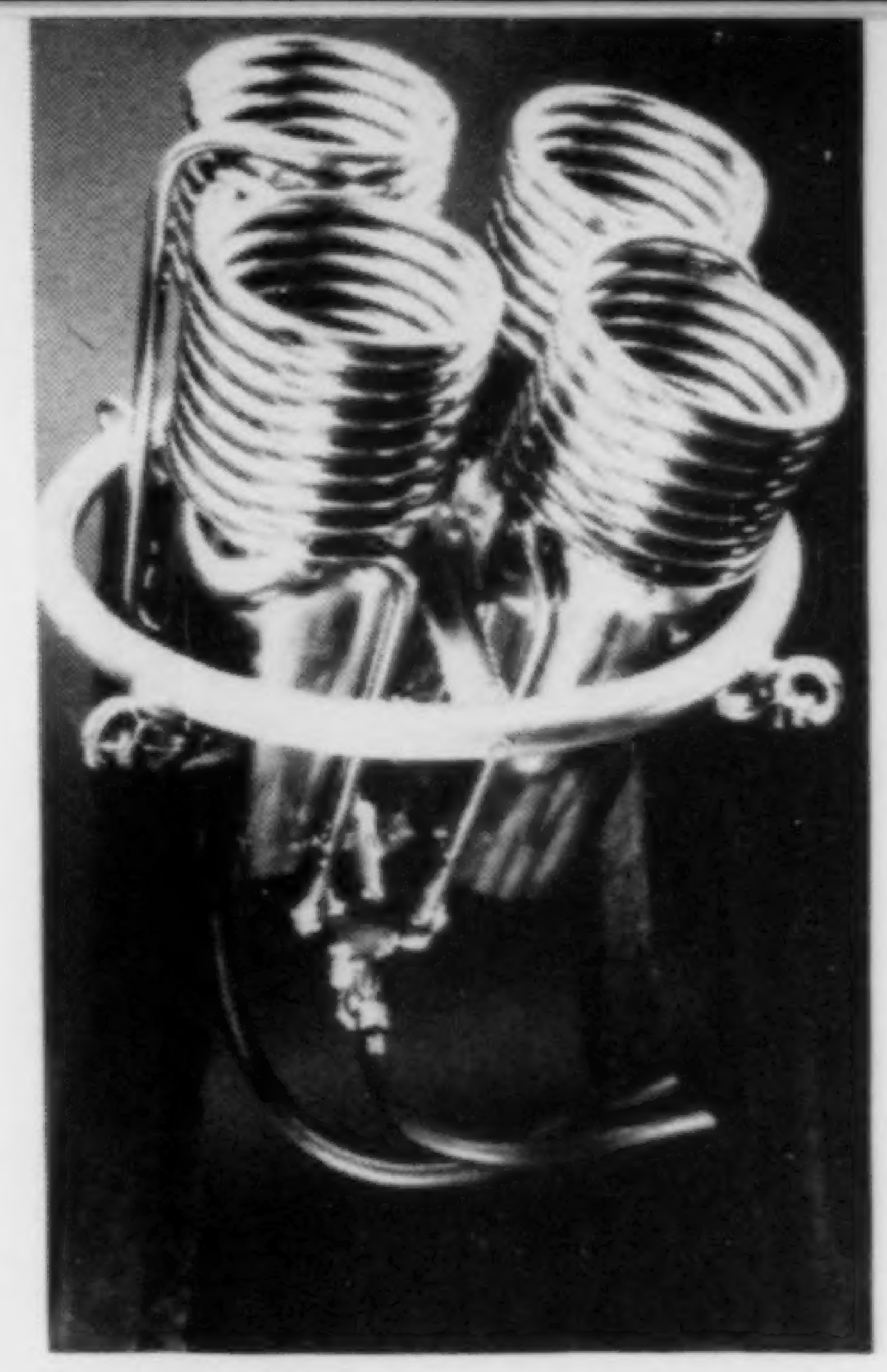
Payload is supported by a crane (left). Load line, parachute and uninflated portion extend behind. A small "bubble" is inflated with helium which expands during ascent. At release (center), balloon gently swings payload off.

PERSONAL BALLOONING

A new hot air balloon (envelope, gondola, burners and instruments) costs $4,200 up. Pilot's training and license could add another $1,000. To take someone on an ascension, owners charge from $100 to $200 per flight. Many owners in Europe and some here accept advertising on the envelope to help offset costs (example, below).

Ballooning is also a beautiful spectator sport. The colors, patterns and occasional whimsy (Santa's reindeer, upper right) make an enchanting sight. *Ballooning* magazine lists meetings and competitions. The best place to see balloons is Albuquerque, New Mexico, where weather is usually ideal.

For data on regulations, write to Flight Standards Office, Federal Aviation Administration, Code AFF-9, Washington, DC 20591. For data on records set, write to National Aeronautic Association, 821 15th St. NW, Washington, DC 20005.



Typical propane burner

N2391R
CRIS
CHE
GAITH

"Wind Shears — We Always Meet Them..."

"Every time we fly we run into wind shears," professional balloon pilot Pat Michaels said to *Air & Space*. "Air is stratified, with a different wind direction every few hundred feet or so; the invisible shear boundaries vary in size and velocity.

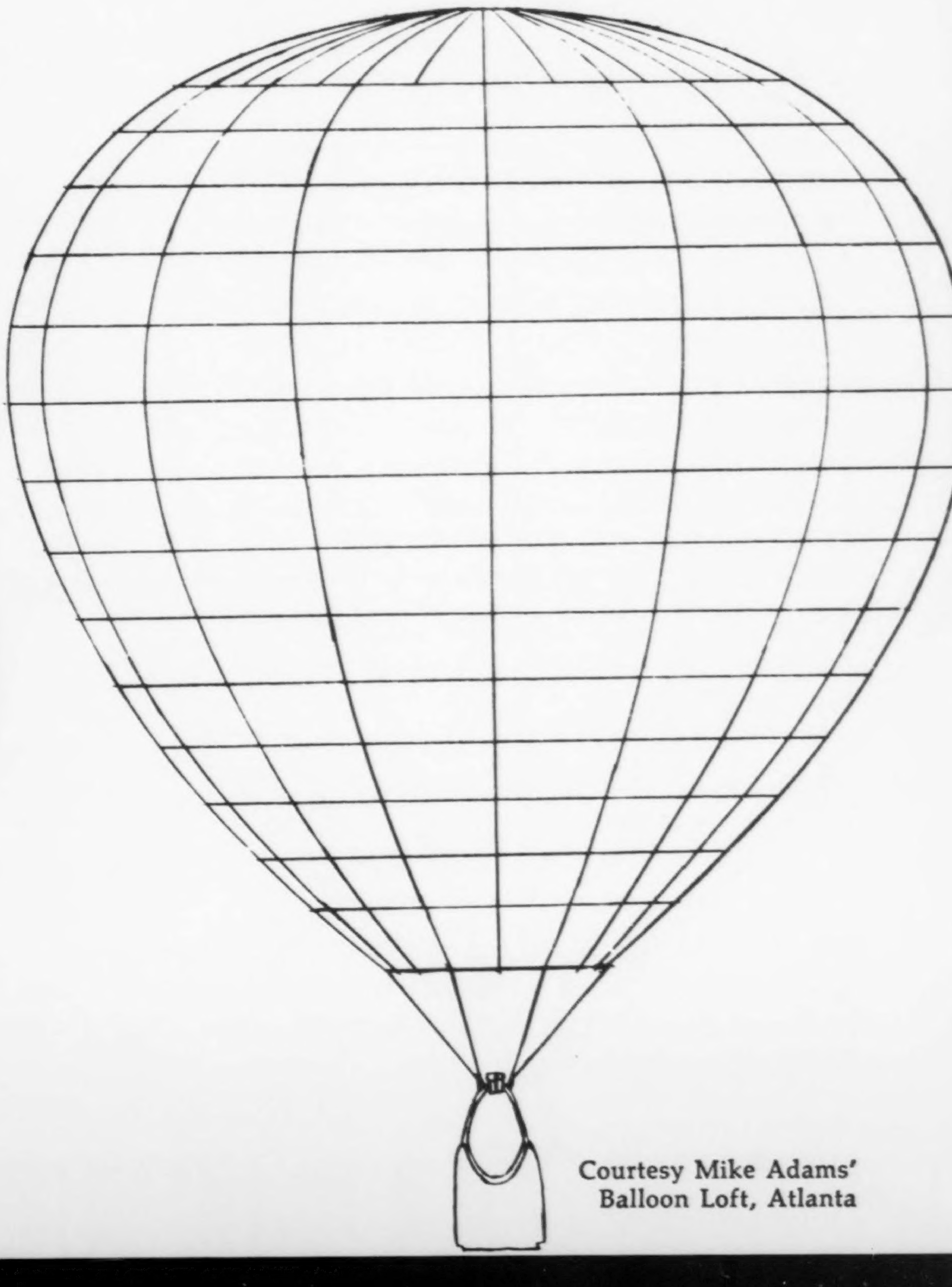
"The top of a balloon is a sort of airfoil. Usually we drift at the same speed as the wind so that there is no airflow over the top, as there is over the wing of an aircraft. But in a shear, air may come faster across the top and we get what's called false lift. This can upset the equilibrium of a balloon—a real hazard if it happens close to the ground.

"Balloonists try to avoid trouble by simply not flying in heavy weather and not at midday, when heat stirs up vertical shears that are hard on a balloon. We get up before dawn and fly early in the day when the air is calmest."

For similar interviews locally, students may call companies listed under BALLOONS—MANNED in the Yellow Pages of the telephone book.

DESIGN A BALLOON

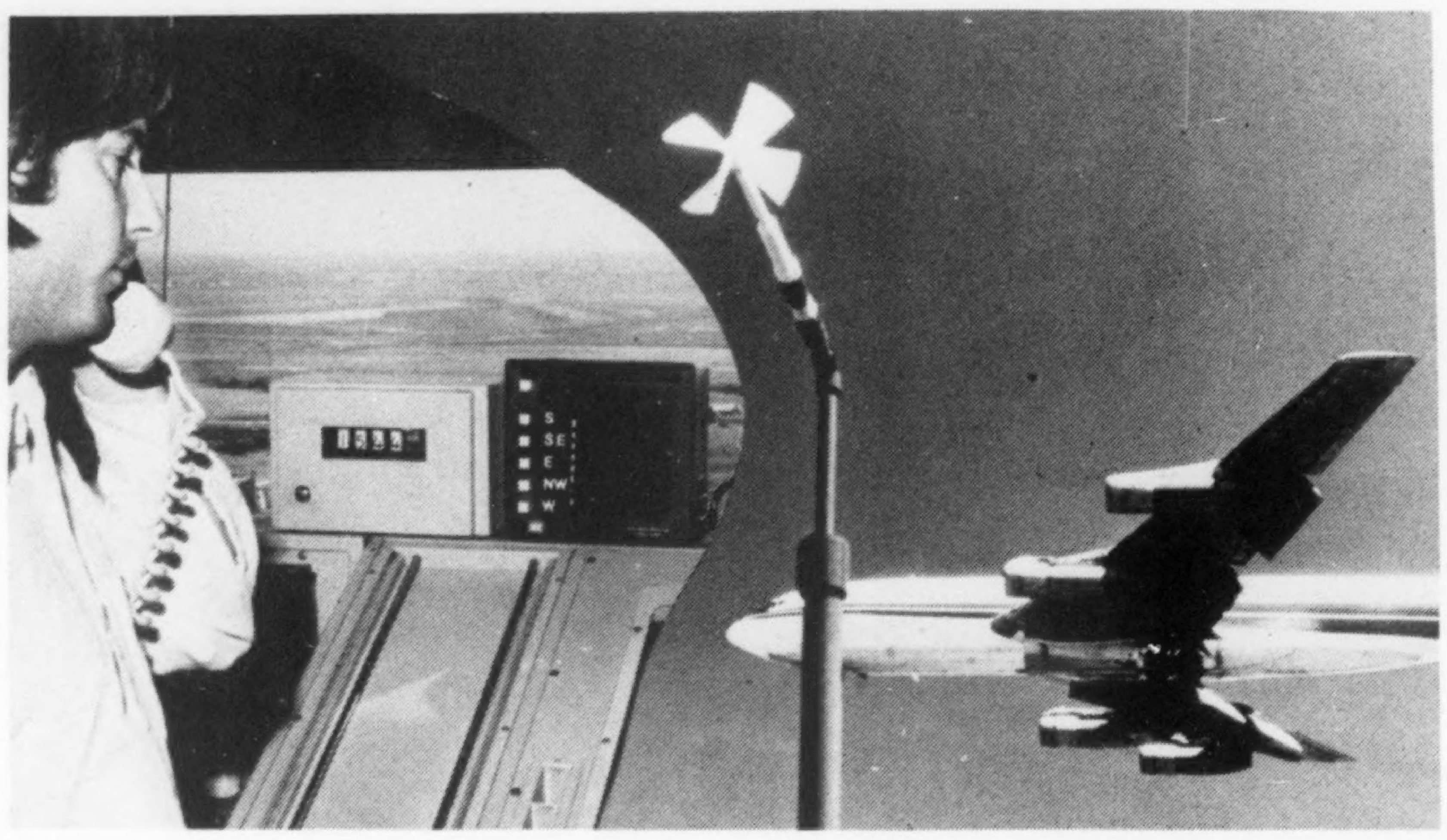
Each section outlined below is a separate piece of fabric, and may be of any standard color the purchaser wants, at no extra cost. Color a pattern.



Courtesy Mike Adams'
Balloon Loft, Atlanta

FAA'S DETECTION SYSTEM CERTIFIED

Airports to Offer Wind Shear Alerts



Students of weather know about wind shear—sudden, drastic shifts in the horizontal speed and/or direction of wind. Meteorologists have recorded adjacent air masses, one racing 100 knots* faster than the other. Such shear is not unexpected around thunderstorms, but can also occur "out of the blue" from fast-moving, invisible weather fronts.

Wind shear is a distinct hazard to aircraft pilots.

The danger is acute during landings or takeoffs when a pilot may not have sufficient altitude to recover from the loss of lift which results from an encounter with wind shear.

Wind shear has been documented as the cause of at least seven U.S. carrier accidents since June 1973, and a possible factor in 25 large-aircraft accidents since 1964. Two years ago, the Federal Aviation Administration (FAA) initiated development of a detection and warning system, giving the job to its research arm, the National Aviation Facilities Experimental Center (NAFEC) near Atlantic City, New Jersey. While still refining their ideas, they put test systems at six airports—Tampa, Atlanta, Houston, Denver, Oklahoma City and New York (cities where students might get first-hand information from air traffic controllers). Boston's Logan Airport has the latest of the system's evolving equipment, added last year. It works so well that it has become the prototype for some 60 additional units. The FAA will install these new systems at airports within three years.

Six wind sensors (the little paddlewheel in the montage above) are mounted on poles 20 to 90 feet tall, depending on terrain. Five surround the airfield about one mile from the ends of the main runways. The sixth is as close as feasible to the geographic center of the airport. Readings from each are radioed to a minicomputer in the Control Tower. If the computer registers more than a predetermined alarm threshold, say a 15-knot wind vector difference between the center and any one of the perimeter sites, then an audible alarm sounds in the Control Tower cab, and a digital display (the black box in the photograph) flashes the direction and speed of the wind noted by the alarming sensor. Air traffic controllers radio the facts to nearby aircraft. Then pilots have such options as adjusting the engine power setting to cope; raising the nose to increase lift (out of a down-shear) while still reducing landing speed; holding (circling above the disturbance for a while); requesting an alternate runway; or flying a "missed approach" and landing at another airport.

NAFEC engineers are working on a version in which data can be transmitted directly to an aircraft.

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* Knot: Speed of one nautical mile per hour, about 1.15 statute miles per hour.

NEW PUBLICATIONS

The first magazine in the new Space Humanization Series is now available from the new Institute for the Social Science Study of Space, an organization outlining future academic disciplines in the social sciences and humanities related to space development. Editors: Dr. T. Stephen Cheston, Associate Dean, Georgetown University Graduate School, and Dr. David Webb. Eight scholarly articles in 125 pages. $5.00 from the Institute, 2135 Wisconsin Ave. NW, Room 401, Washington, DC 20007.

Aerospace, the Challenge, new 180-hour course textbook for high schools, by Civil Air Patrol; 8½ by 11 in., hard cover, 640 pp., illus., biblio., film list, activities, index. Available in July; price not set at the time of this writing. Inquire: Book Store, CAP, Maxwell Air Force Base, Alabama 36112.

Aerospace Correspondence Course

A year-long, high school correspondence course in Aerospace Education was inaugurated last fall by Indiana University, and, according to the planners, provides credit toward graduation in any high school of the U.S. This is an aid to especially interested or gifted students in schools which offer no aerospace work.

As of 1978, tuition was $25, the Study Guide $4, the required textbook $15. Developed at Indiana, the program was edited by Dr. James J. Wagner, Purdue University, chairman of the Indiana Aerospace Education Council. For details, address Dr. Larry Keller or Dr. Frank DiSilvestro, Correspondence Studies Division, Indiana University, Owen Hall, Bloomington, Indiana 47405.

Purdue University put aerospace into the 4-H program. About 200 000 young people are now involved, in 50 states, and some have earned their private pilot licenses. For information, address Dr. Ed Frickey, 4-H Programs, Purdue University, Ag Hall, West Lafayette, Indiana 47907.

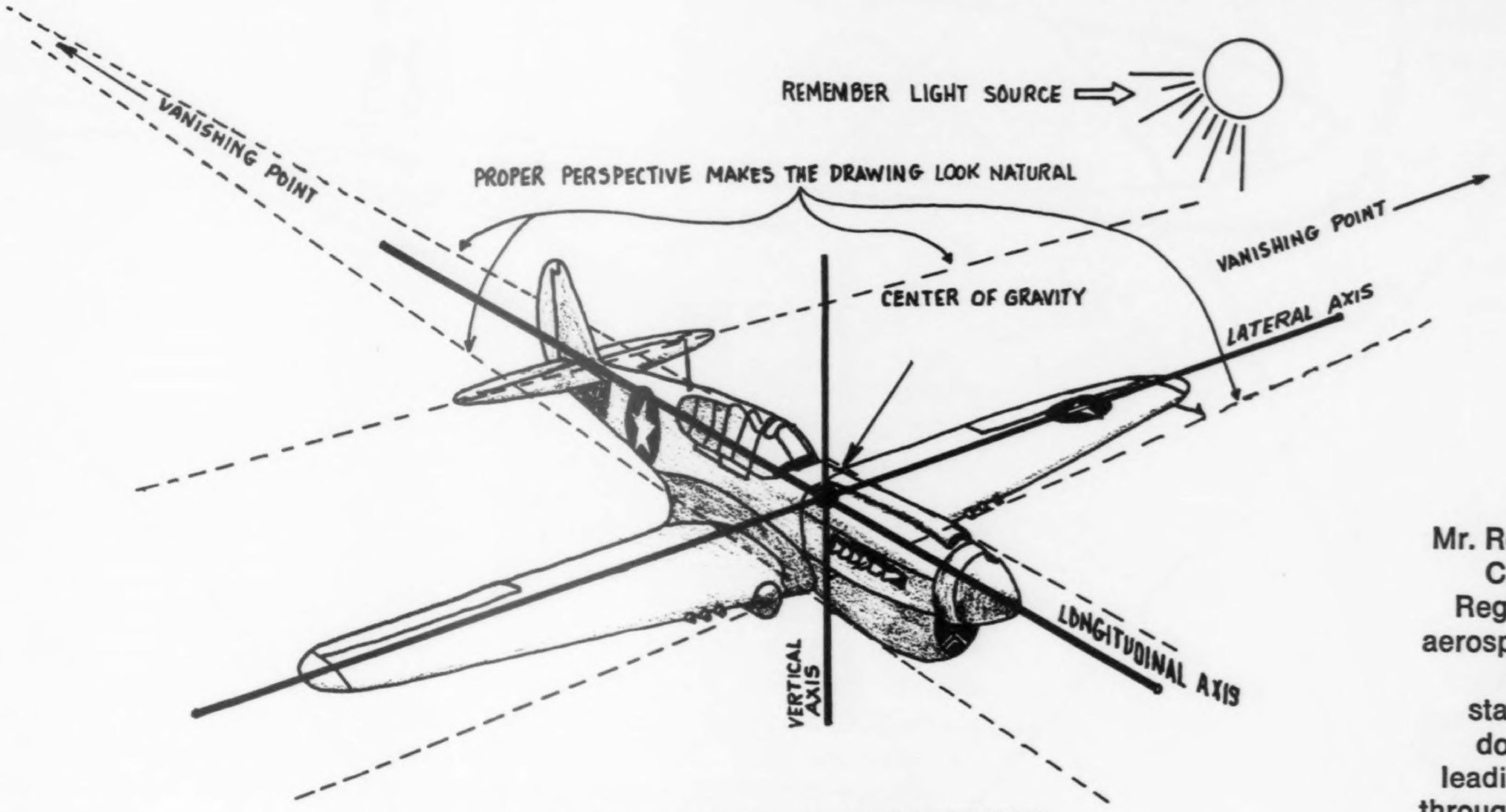
Letter to Editor

The March issue of Air & Space announced the new biennial (3rd) edition of our Directory of Aviation/Space Education. Checks were to be sent to the address below. We are pleased to say now that this resource guide will be printed by a federal agency for free distribution. Therefore any checks received will be returned immediately, and we will advise readers when the new Directory becomes available in about six months. Anyone ordering the current Directory (2nd Ed.) at $2.95 will automatically receive the third edition also, later.

Wayne R. Matson, Executive Director
American Society for Aerospace Education
1750 Pennsylvania Ave. NW, Suite 1303
Washington, DC 20006

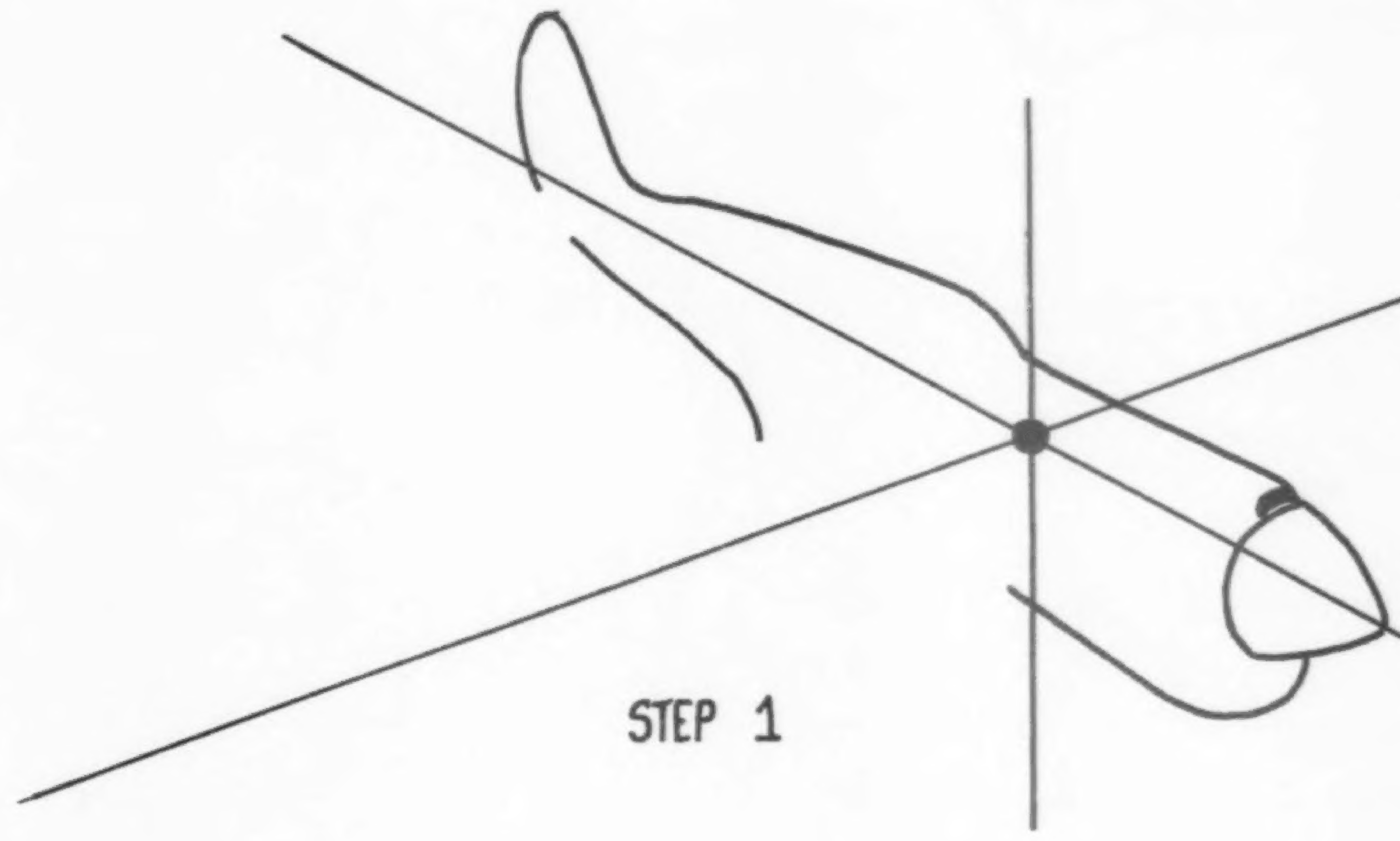
THE SECRET OF SKETCHING AIRCRAFT

Bill Reynolds, artist, fighter pilot, flight instructor, aerospace educator, has taught many a teacher how to awe the class by nonchalantly chalking a fine, full-bodied aircraft on the blackboard. The way to do it is herewith revealed.

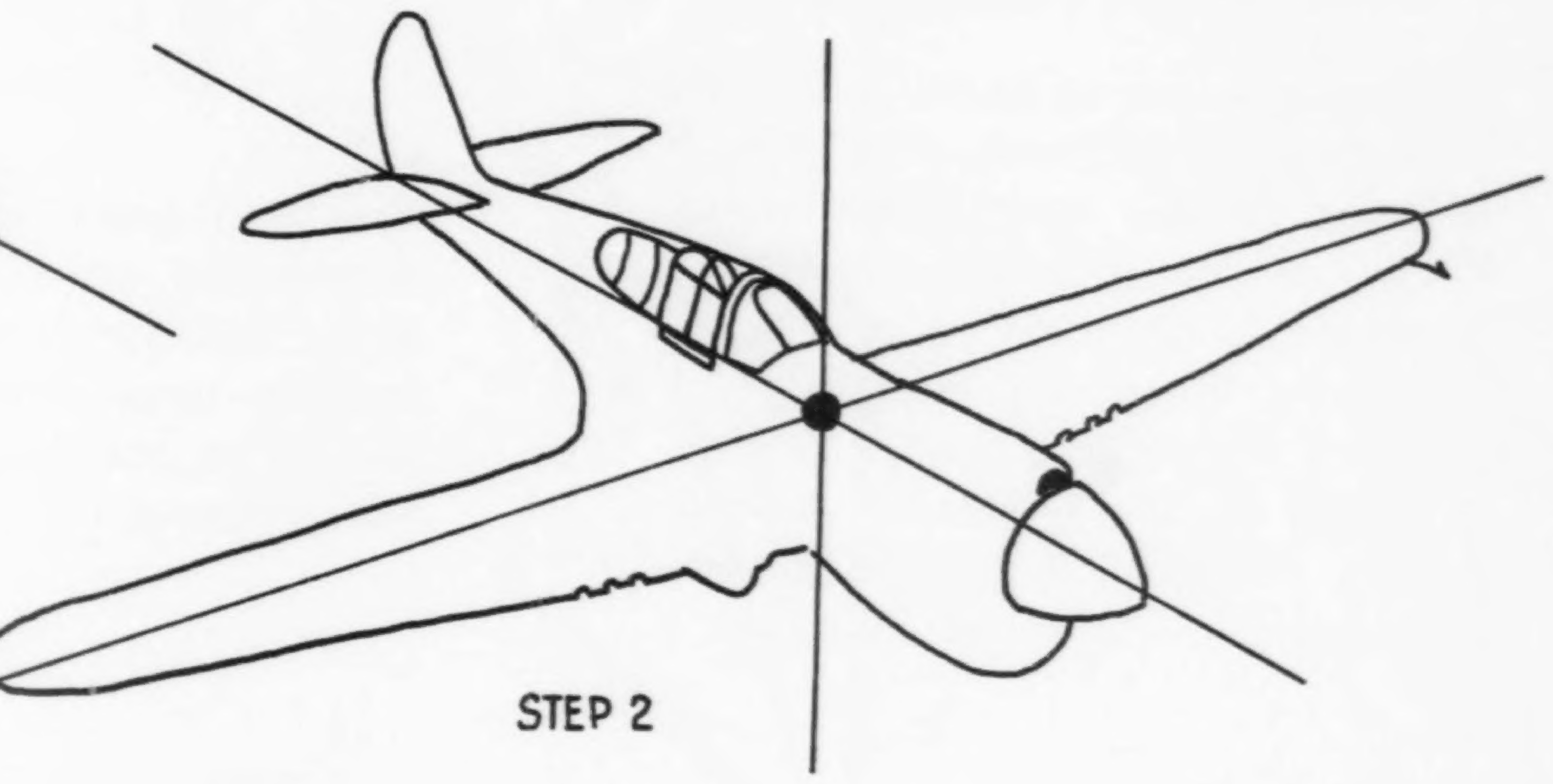

REMEMBER LIGHT SOURCE
VANISHING POINT
PROPER PERSPECTIVE MAKES THE DRAWING LOOK NATURAL
VANISHING POINT
CENTER OF GRAVITY
LATERAL AXIS
LONGITUDINAL AXIS
VERTICAL AXIS

BUILD THE AIRCRAFT AROUND THE CENTER OF GRAVITY, AND THE THREE AXIS OF ROTATION WHEN THEY ARE DETERMINED AND LIGHTLY DRAWN.

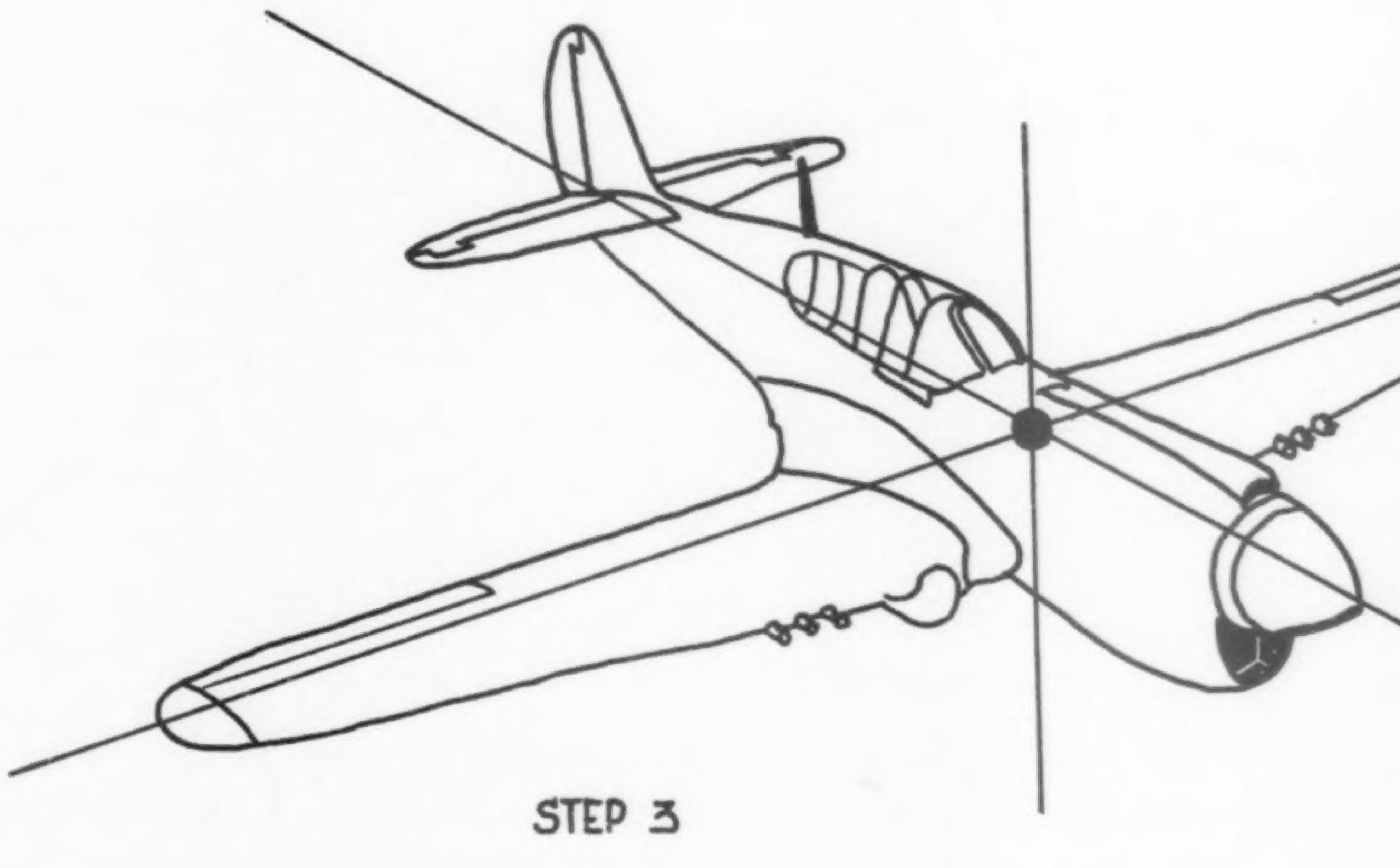
Mr. Reynolds is now Civil Air Patrol's Region Director of aerospace education in east-central states, and also a docent at NASM, leading tour groups through the Museum. During World War II in the Pacific, he flew P-40s, the plane sketched here.



STEP 1

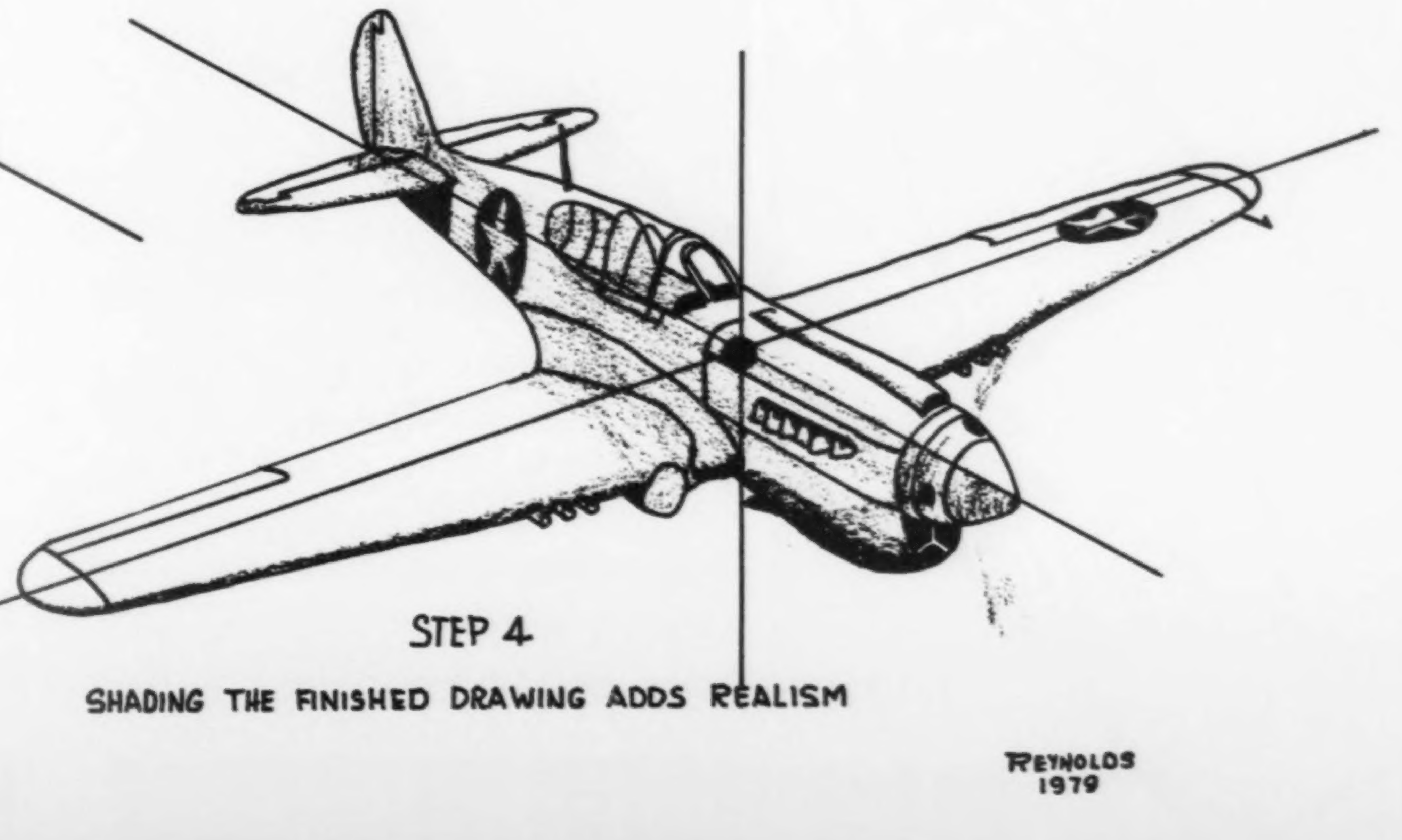


STEP 2



STEP 3

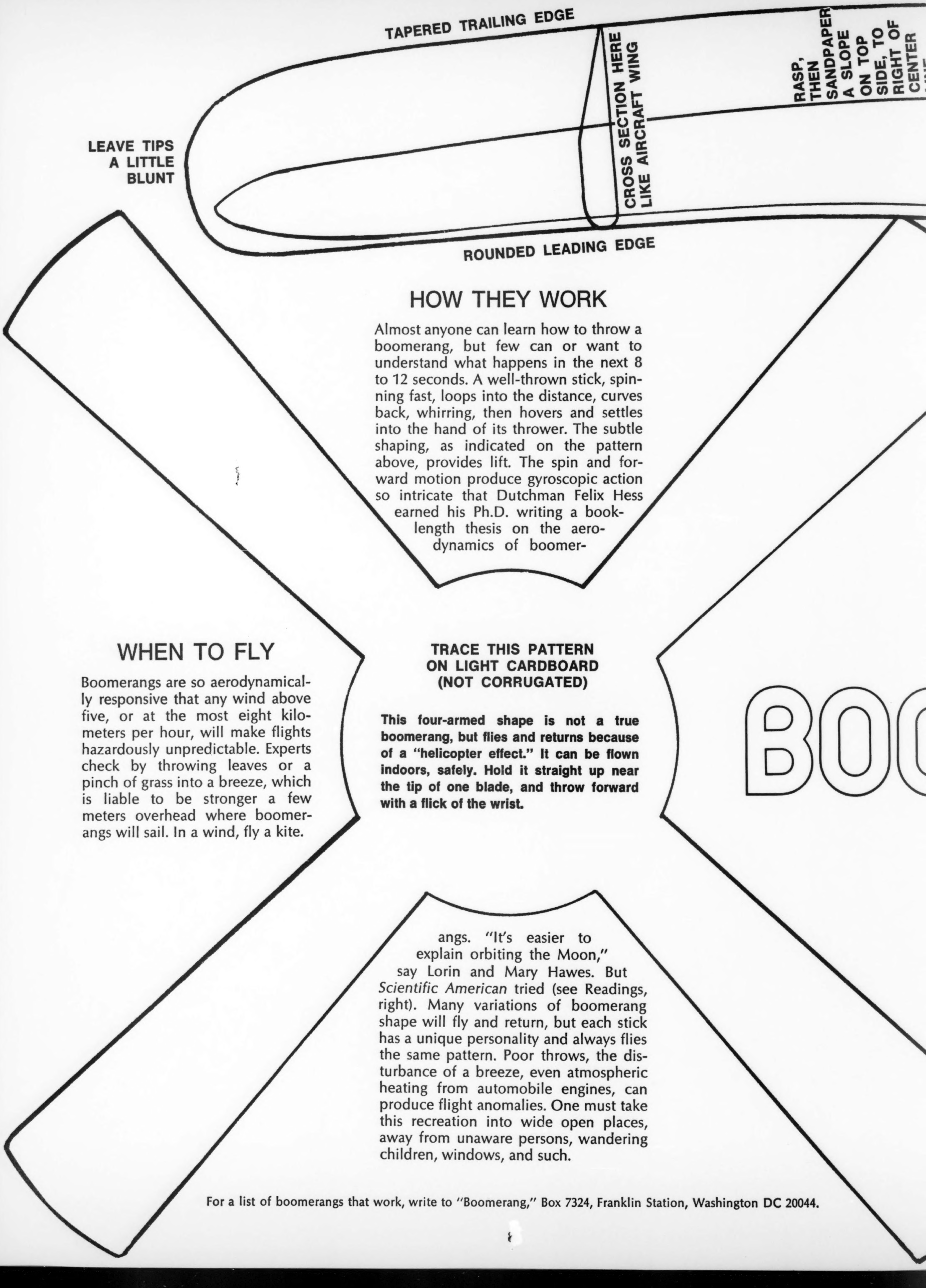
AN AIRPLANE, LIKE PEOPLE HAS A SKELETON COVERED WITH SKIN.



STEP 4

SHADING THE FINISHED DRAWING ADDS REALISM

REYNOLDS 1979


TAPERED TRAILING EDGE
LEAVE TIPS A LITTLE BLUNT
CROSS SECTION HERE LIKE AIRCRAFT WING
RASP, THEN SANDPAPER A SLOPE ON TOP SIDE, TO RIGHT OF CENTER
ROUNDED LEADING EDGE
BOO

HOW THEY WORK

Almost anyone can learn how to throw a boomerang, but few can or want to understand what happens in the next 8 to 12 seconds. A well-thrown stick, spinning fast, loops into the distance, curves back, whirring, then hovers and settles into the hand of its thrower. The subtle shaping, as indicated on the pattern above, provides lift. The spin and forward motion produce gyroscopic action so intricate that Dutchman Felix Hess earned his Ph.D. writing a book-length thesis on the aerodynamics of boomerangs. "It's easier to explain orbiting the Moon," say Lorin and Mary Hawes. But *Scientific American* tried (see Readings, right). Many variations of boomerang shape will fly and return, but each stick has a unique personality and always flies the same pattern. Poor throws, the disturbance of a breeze, even atmospheric heating from automobile engines, can produce flight anomalies. One must take this recreation into wide open places, away from unaware persons, wandering children, windows, and such.

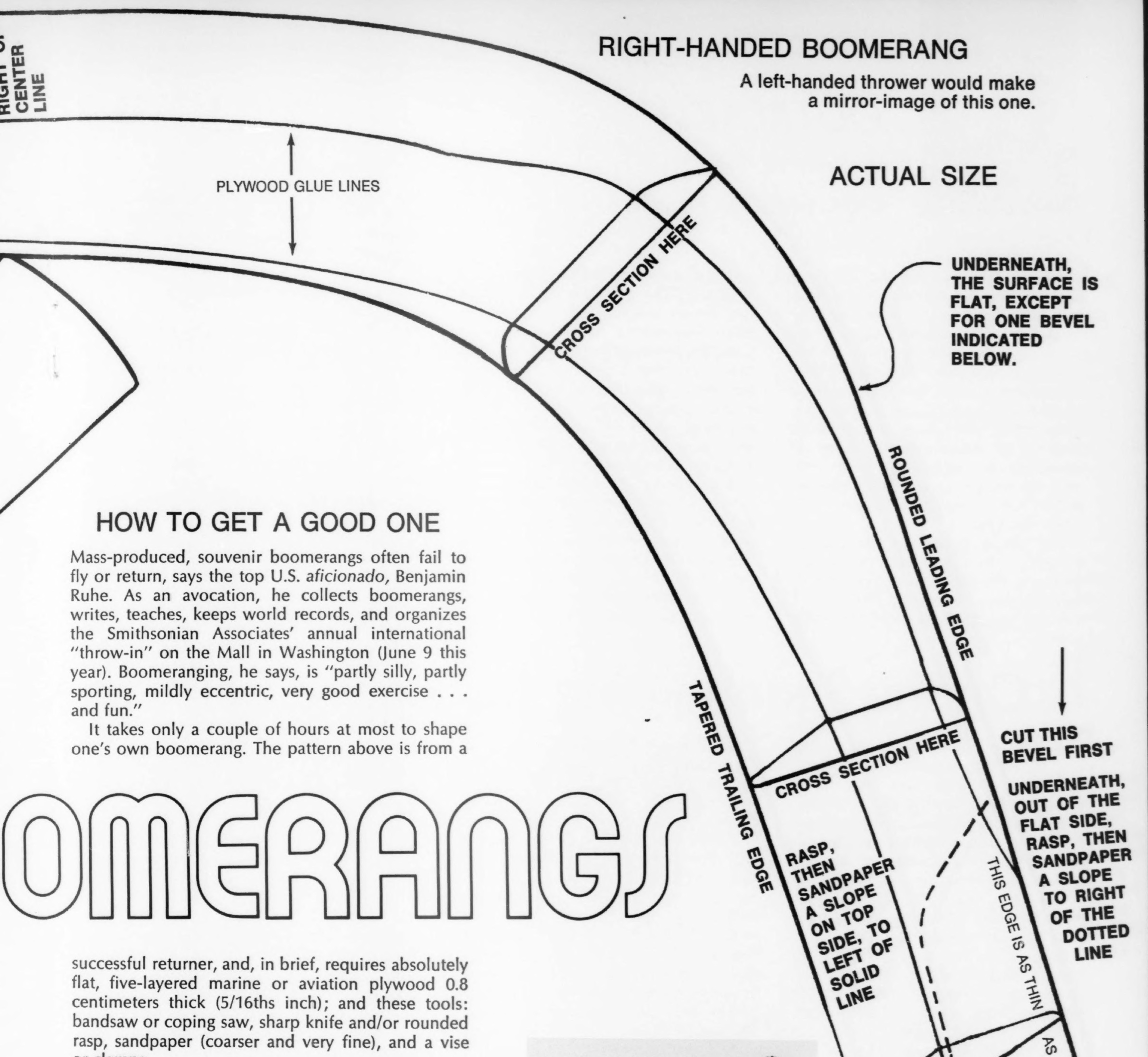
WHEN TO FLY

Boomerangs are so aerodynamically responsive that any wind above five, or at the most eight kilometers per hour, will make flights hazardously unpredictable. Experts check by throwing leaves or a pinch of grass into a breeze, which is liable to be stronger a few meters overhead where boomerangs will sail. In a wind, fly a kite.

**TRACE THIS PATTERN
ON LIGHT CARDBOARD
(NOT CORRUGATED)**

This four-armed shape is not a true boomerang, but flies and returns because of a "helicopter effect." It can be flown indoors, safely. Hold it straight up near the tip of one blade, and throw forward with a flick of the wrist.

For a list of boomerangs that work, write to "Boomerang," Box 7324, Franklin Station, Washington DC 20044.


RIGHT
CENTER
LINE
RIGHT-HANDED BOOMERANG
A left-handed thrower would make a mirror-image of this one.
ACTUAL SIZE
PLYWOOD GLUE LINES
CROSS SECTION HERE
UNDERNEATH, THE SURFACE IS FLAT, EXCEPT FOR ONE BEVEL INDICATED BELOW.
ROUNDED LEADING EDGE
TAPERED TRAILING EDGE
CROSS SECTION HERE
CUT THIS BEVEL FIRST
UNDERNEATH, OUT OF THE FLAT SIDE, RASP, THEN SANDPAPER A SLOPE TO RIGHT OF THE DOTTED LINE
RASP, THEN SANDPAPER A SLOPE ON TOP SIDE, TO LEFT OF SOLID LINE
THIS EDGE IS AS THIN AS THE TRAILING EDGE
CROSS SECTION HERE LIKE AIRCRAFT PROPELLER

HOW TO GET A GOOD ONE

Mass-produced, souvenir boomerangs often fail to fly or return, says the top U.S. *aficionado,* Benjamin Ruhe. As an avocation, he collects boomerangs, writes, teaches, keeps world records, and organizes the Smithsonian Associates' annual international "throw-in" on the Mall in Washington (June 9 this year). Boomeranging, he says, is "partly silly, partly sporting, mildly eccentric, very good exercise . . . and fun."

It takes only a couple of hours at most to shape one's own boomerang. The pattern above is from a successful returner, and, in brief, requires absolutely flat, five-layered marine or aviation plywood 0.8 centimeters thick (5/16ths inch); and these tools: bandsaw or coping saw, sharp knife and/or rounded rasp, sandpaper (coarser and very fine), and a vise or clamps.

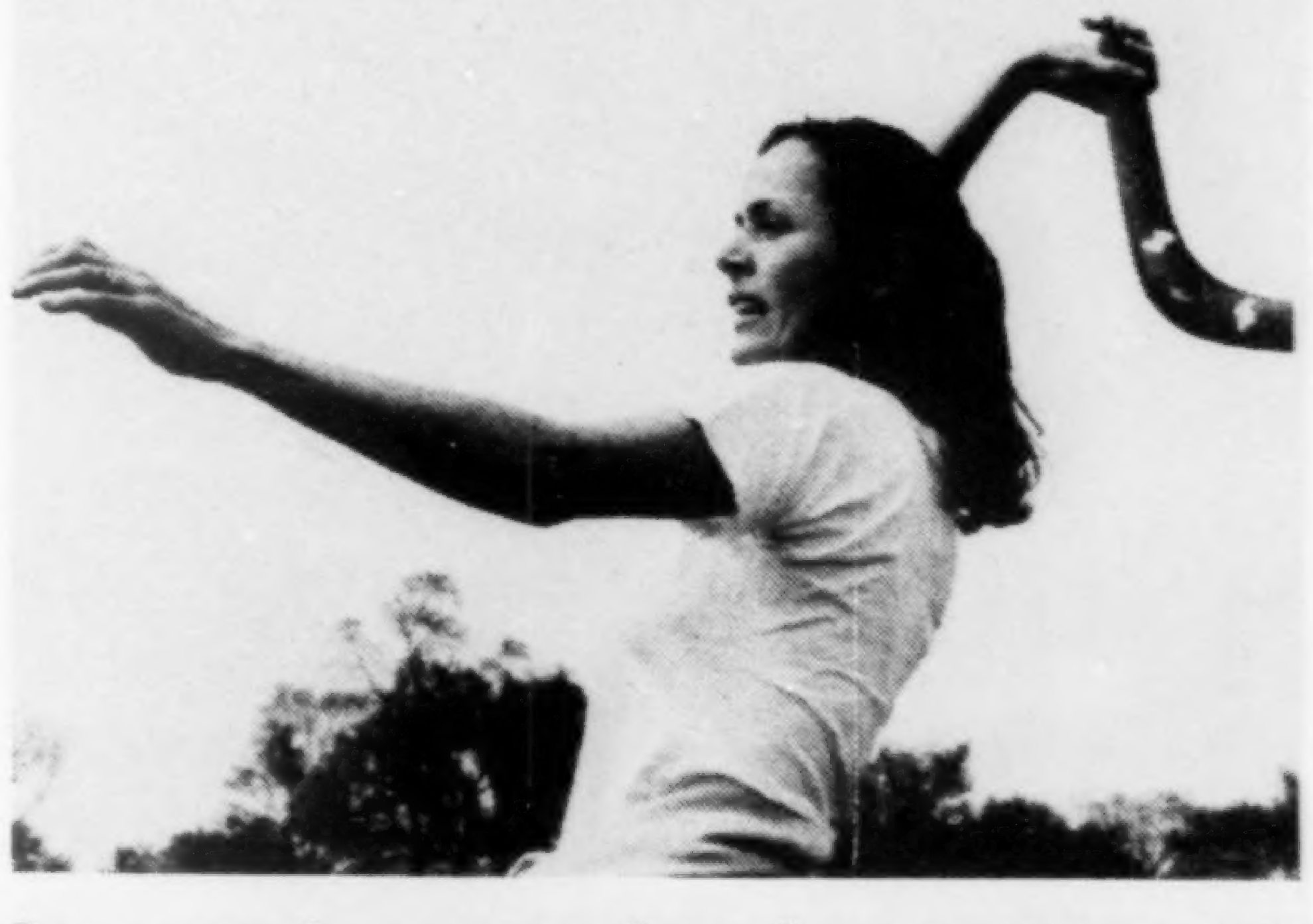
OMERANGS

Boomerangs involve the most delicate subtleties; of two that look identical, one may return and the other may not. Even tough-minded experts can be caught using the word "mysterious" about boomerang aerodynamics. Makers always test-fly their handiwork, and can reshape to correct any problems, according to advice in the books. Finishes may be varnish, shellac, paint, shoe or furniture polish.

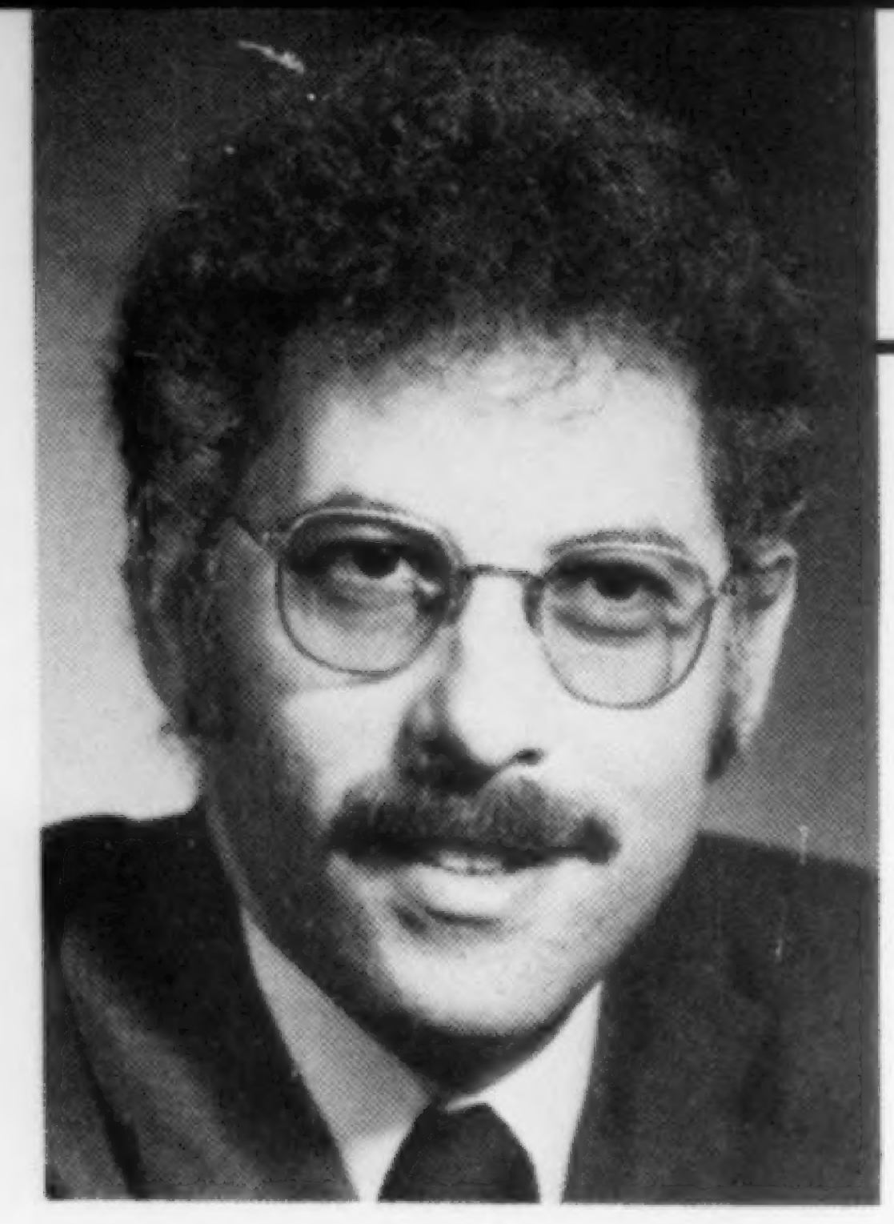
Readings: *Many Happy Returns: The Art and Sport of Boomeranging,* Benjamin Ruhe, 105 pp., illus. biblio. Viking Press, New York, 1977.

All About Boomerangs, Lorin and Mary Hawes, 72 pp., illus, index. Paul Hamlyn Pty. Ltd., 176 S. Creek Rd., Dee Why West, Sydney, Australia NSW 2099, 1975.

Scientific American, March and April 1979, "The Amateur Scientist" section.



An expert grasps her boomerang near one tip, the flat side outward, the stick upright, and at release, tilted about 30° from the vertical, aimed at the horizon. The crook of the forefinger imparts the essential spin. Boomerangs may be thrown by either end; the flight paths differ.



OUTREACH

by Kerry M. Joëls

Chief, Education Division

Someone once told me that the three best reasons for teaching were June, July and August . . . now times for remedial and summer classes, inservice training and planning for the coming school year. With professional advancement often tied to completion of additional course work or professional units, there is a great drive for teachers to cover a wide range of extracurricular subject matter in summer workshops. Over 10 000 teachers will attend aerospace education workshops this year.

This group is perhaps the greatest outreach that aerospace education makes to the children of this country, since aerospace education leaders pour much effort into supporting the local and regional workshop activities.

One of the themes that aerospace has always emphasized has been to teach fundamental curricular concepts using the wide variety of aviation and space problems. Truly aerospace covers the gamut of scientific, technical and even social problems. Support efforts like those of the National Aeronautics and Space Administration, the Federal Aviation Administration, the Civil Air Patrol and the American Society for Aerospace Education have always tried to make the aerospace curriculum relevant to the mainstream of elementary and secondary school activities. But should we do more? Aerospace concepts form the basis of future technological development, and social options which can overwhelm the unprepared. The potentials of space shuttle technology and hypersonic air travel coupled with the more mundane proliferation of modern jet travel and application satellite technology are still foreign to the bulk of educational users. These teachers and students need to be brought into the mainstream of "aerospace thinking." The impact of direct and derivative aerospace technologies has been so great on our society that we owe them preparation for the future.

The affective or emotional aspects of interaction by a teacher with aviation and space topics should be explored and expanded. Our workshops and our outreach should strive to communicate the meaning, potential, pitfalls, and personal and social triumphs that have and will result from human endeavor in the aerospace effort.

On the Summertime Aerospace Trail

The summer vacationer who would like to trail aeronautical events and aerospace exhibits can find them throughout this country and abroad.

The National Air and Space Museum is the most comprehensive showcase in the world. The Balloons and Airships Gallery fully illustrates the brief story in this issue, and adds material about the powered, steerable, sometimes rigid balloons called airships.

Ballooning, the magazine of The Balloon Federation of America, includes lists of events. If public libraries have had the same experience as NASM, constantly losing copies, issues may be kept in an office for special requests. The 1979 editor is Brian Lawler, 2226 Beebee St., San Luis Obispo, California 93401.

A famed annual event in the history of gas ballooning, the international Gordon Bennett Cup Races, will be revived May 22 at Long Beach, California. Races had been held from 1905 to 1938 in the nation of the previous year's winner. Participants from several nations will try this year for the greatest distance from the point of ascension, the parking lot for the *"Queen Mary"* near downtown Long Beach. With some modernization, the rules are nearly identical to those last updated by Orville Wright for the 1927 race.

In Tokyo, the spectacular Space Expo remains open through September 2. Major exhibits were sent by the U.S., the U.S.S.R. and other nations.

In Oshkosh, Wisconsin, the Fly-in Convention and Sport Aviation Exhibition, July 28-August 4, will probably attract no fewer than the 350 000 persons who flew-in or drove-in last summer. During the eight days last year, 64 839 flight operations made Wittman Field at Oshkosh the busiest airport in the world. Many aircraft are the handiwork of high school or college students in programs organized by the sponsor of the Fly-in, the Experimental Aircraft Association (EAA). Members may camp on the EAA grounds. Others usually fill the major hotels as far away as Milwaukee (90 miles). But, says EAA's Ben Owen, "With a good road map, one can find small motels in small towns nearby."

At Fond du Lac, 30 miles south, an aircraft aerobatic competition August 6 - 11 will include many home- or school-built planes.

NASA Centers welcome visitors: Ames (Mountain View, California)*; Johnson (Houston, Texas); Lewis (Cleveland, Ohio); Kennedy (Cape Canaveral, Florida); Marshall (Huntsville, Alabama); Goddard (Greenbelt, Maryland, a Washington suburb); Langley (Hampton, Virginia) and Wallops Island, Virginia*. Three communications satellites will be launched this summer from Kennedy Space Center: Fleetsatcom in May, Westar C in July, Intelsat V-A in August. For exact dates, call Public Information at Kennedy: 305/867-2468.

It would be impossible to list all of the museums showing aviation and/or space artifacts. Library reference departments may have the following (and other) directories:

Aviation and Space Museums of America, Jon L. Allen, 287 pp., illus., small chapters for each organization presented geographically: 8 listings for the northeastern U.S.; 15 for the southeast; 13 for the midwest; 10 for the southwest; 8 for the west; 3 in Canada. Arco Publishing Co., Inc., 219 Park Ave. S., New York, NY 10003, 1975, $12.

Aircraft Museum Directory, paperback, 72 pp., illus., basic data about 41 exhibit centers in the U.S. Quadrant Press, Inc., 19 W. 44th St., Suite 707, New York, NY 10036, 1976, $2.25.

Astronomical Directory, 8½ by 11 in., paperback, 144 computer pages, brief information about more than 3,000 planetariums, observatories, publications, suppliers and amateur astronomy clubs in 62 nations. Gall Publications, 1293 Gerrard St. E., Toronto, Canada M4L 1Y8, 1978, $8.00, shipped postpaid.

*** By appointment.**

Payloads Aboard Shuttle

HOW THEY THRUST ABOVE LOW-EARTH-ORBIT

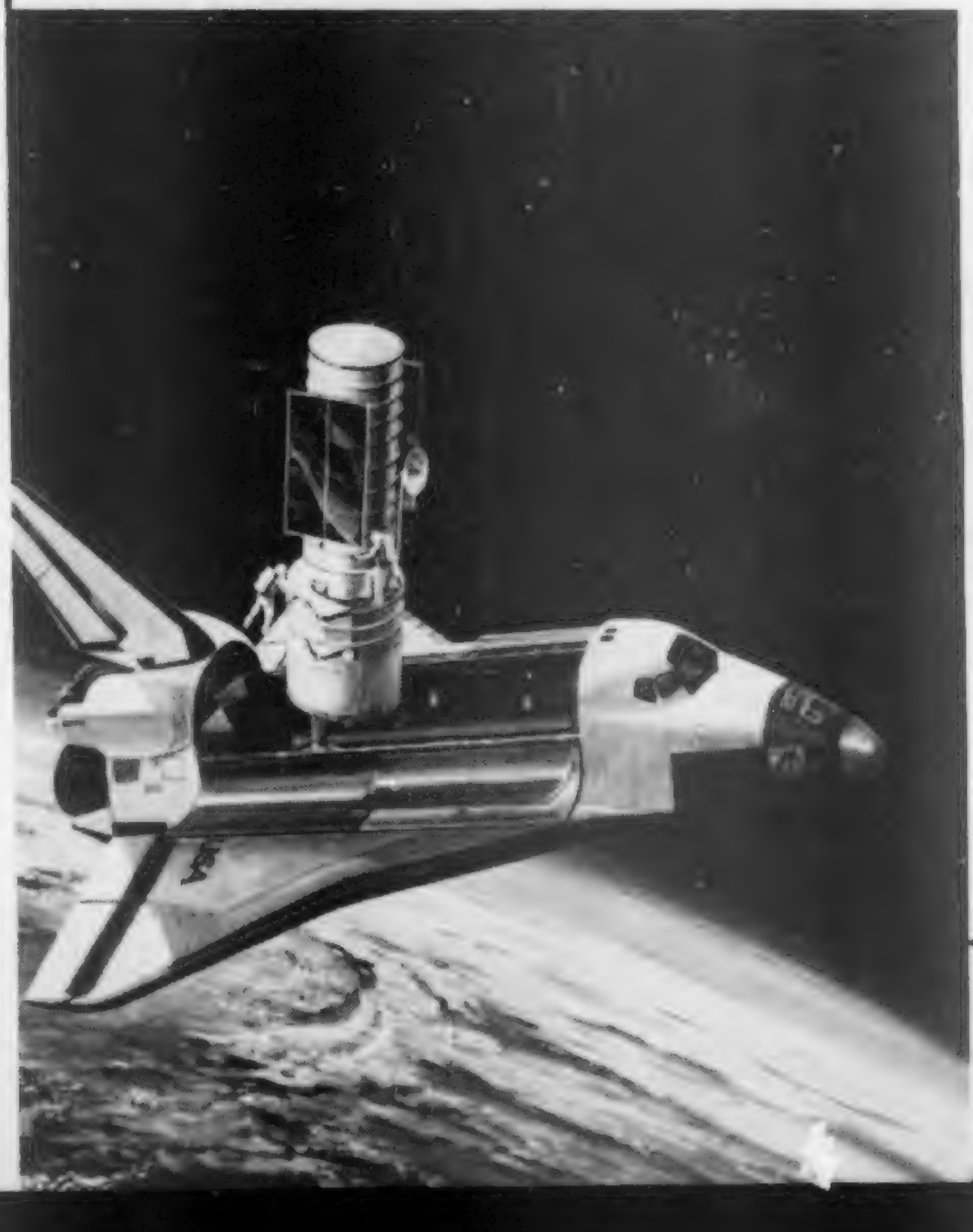
When the Shuttle begins round trips to space, it becomes the primary launch system of the U.S. for both civilian and military missions. But the orbiters make only a short foray into space.

In the diagram to the right, the arcs represent six of 4600 orbit paths now in use around this planet. Shuttle's usual parking orbit will be low, only 300 kilometers overhead. With reduced loads, orbiters can be sent farther out, but nowhere near the delivery point for many payloads they will fly.

Current launches are custom-tailored all the way. Payloads are boosted on a Scout, a Delta, an Atlas-Centaur, or a Titan III, according to the weight to be lifted and destination. Usually two or three stages fire in succession, and all are discarded. These expendable launch vehicles are based on "throw-away" ballistic missile technology.

Years ago, NASA started planning a reuseable launch vehicle. Shuttle is a practicable compromise, a better first stage for two reasons: (1) Everything is reuseable except the external tank which feeds liquid propellants to the orbiter's three engines during launch; and (2) an orbiter can carry 29 500 kilograms in its 4.5 by 18 meter payload bay, more bulk and weight than any one of the expendable launchers. While there will be single payloads at times, more often several spacecraft and scientific experiments will share the payload bay, and share costs. There are four means by which spacecraft can go farther than the parking orbit.

Below, the Space Telescope will be launched in 1983 on a "dedicated flight," that is, as the only payload on board.



1. Shuttle Variations

Shuttle's basic operation can deliver the maximum (29 500 kilogram) payload to 300 kilometers altitude. But with adjustments in weight and fuel, orbiters can reach many different areas of near-Earth space.

For instance, in late 1983, an orbiter will take the Space Telescope directly to its assigned 555 km altitude (artist's concept to the left). The telescope, its solar panels and associated instrumentation will weigh about 11 000 kg. With such payloads that weigh less than the maximum, an orbiter has extra capability.

Orbiter 102 can be sent into elliptical paths with an apogee up to 3000 km—if the payload is one-third the maximum, and if extra fuel is taken in three Orbital Maneuvering Subsystem kits (OMS) installed in the payload bay. With one-third maximum load and three OMS, an orbiter can reach a circular path 1200 km from Earth. Additional flexibility can come from changing the inclination of the launch (angle between the plane of the orbit and the equatorial plane). A launch due east of any launch site takes maximum advantage of the free, extra velocity imparted by Earth's rotation, 411.48 meters/second. Kennedy Space Center is at 28.5° N. latitude; launches due east are at a 28.5° inclination. Any change requires lessening payload weight.

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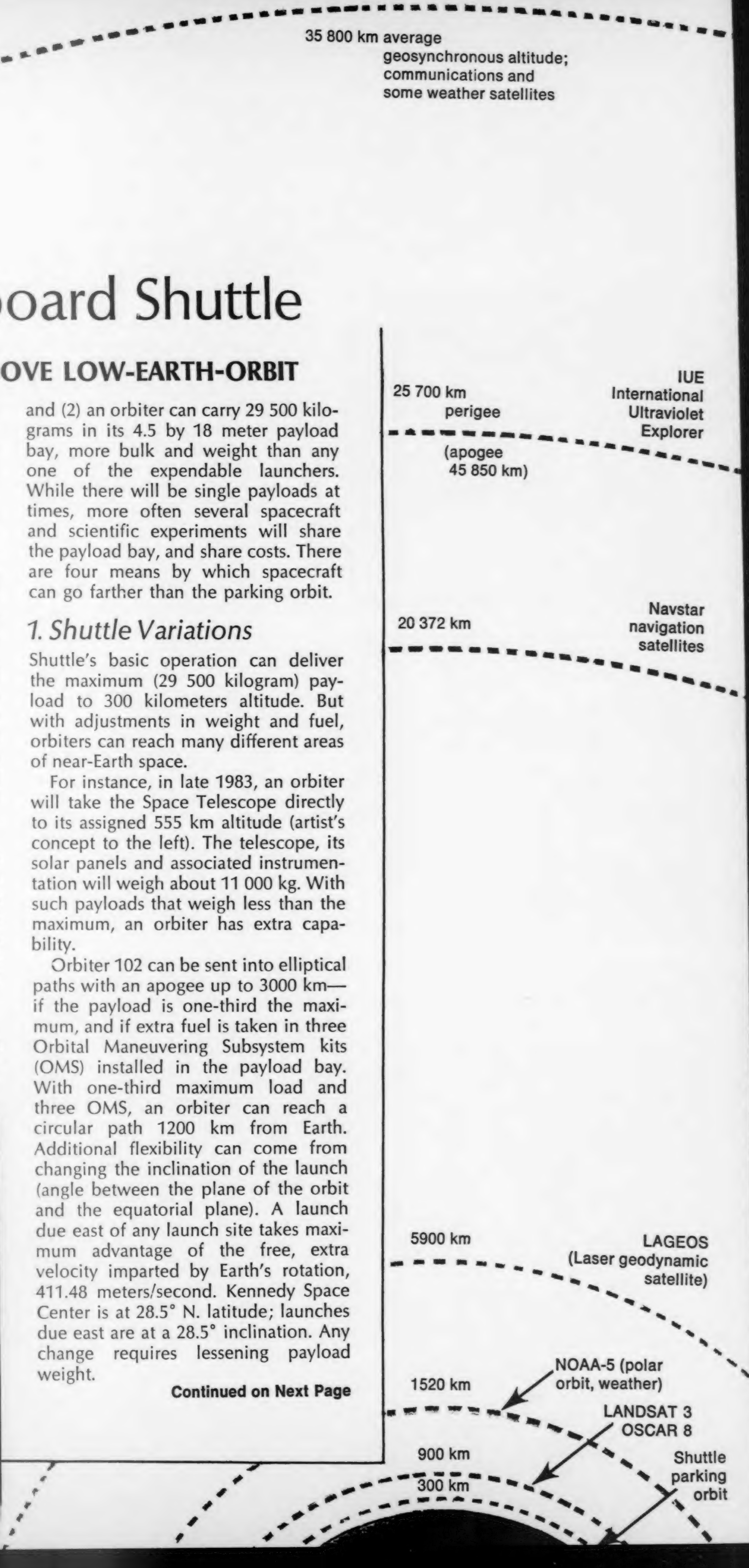
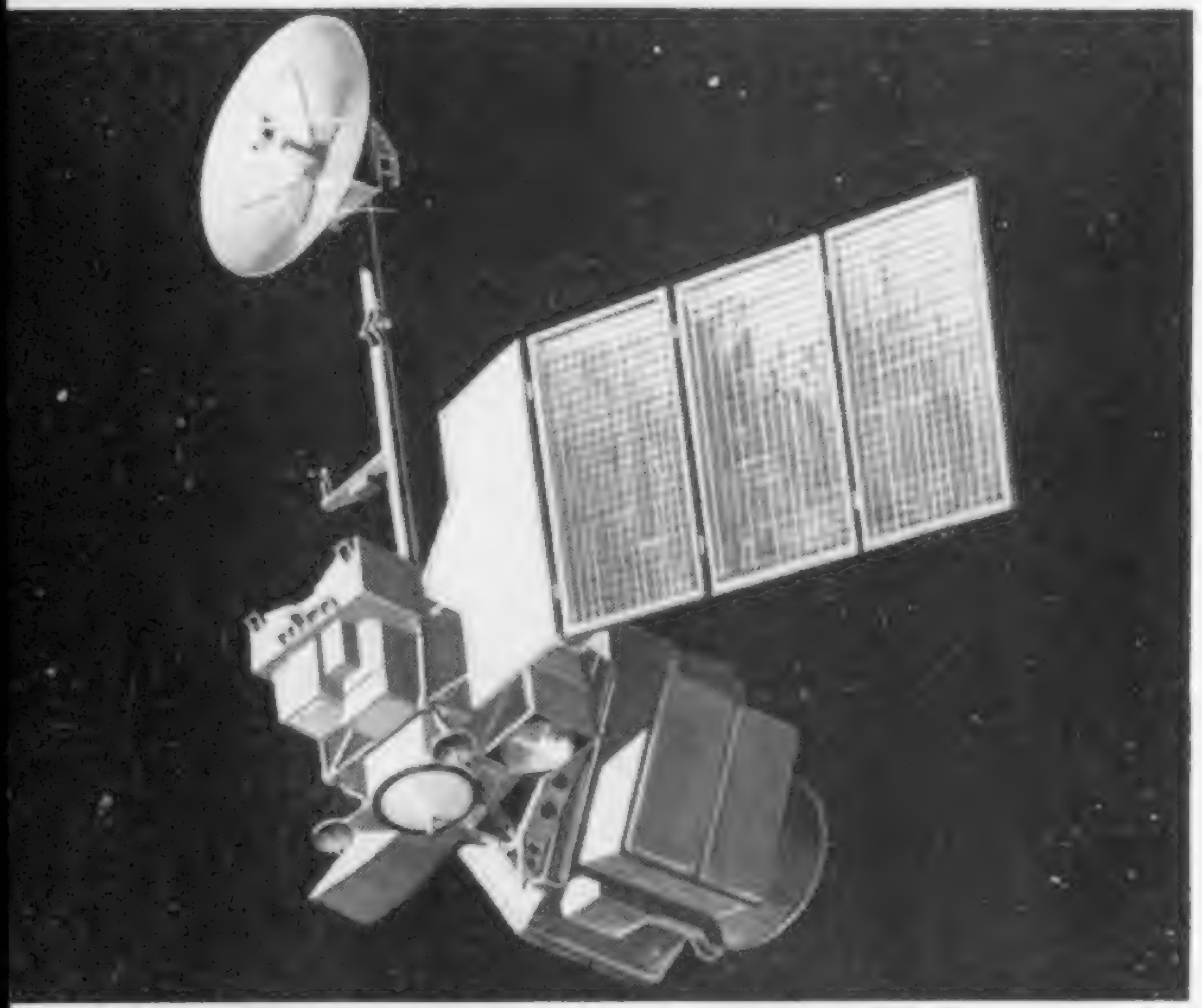
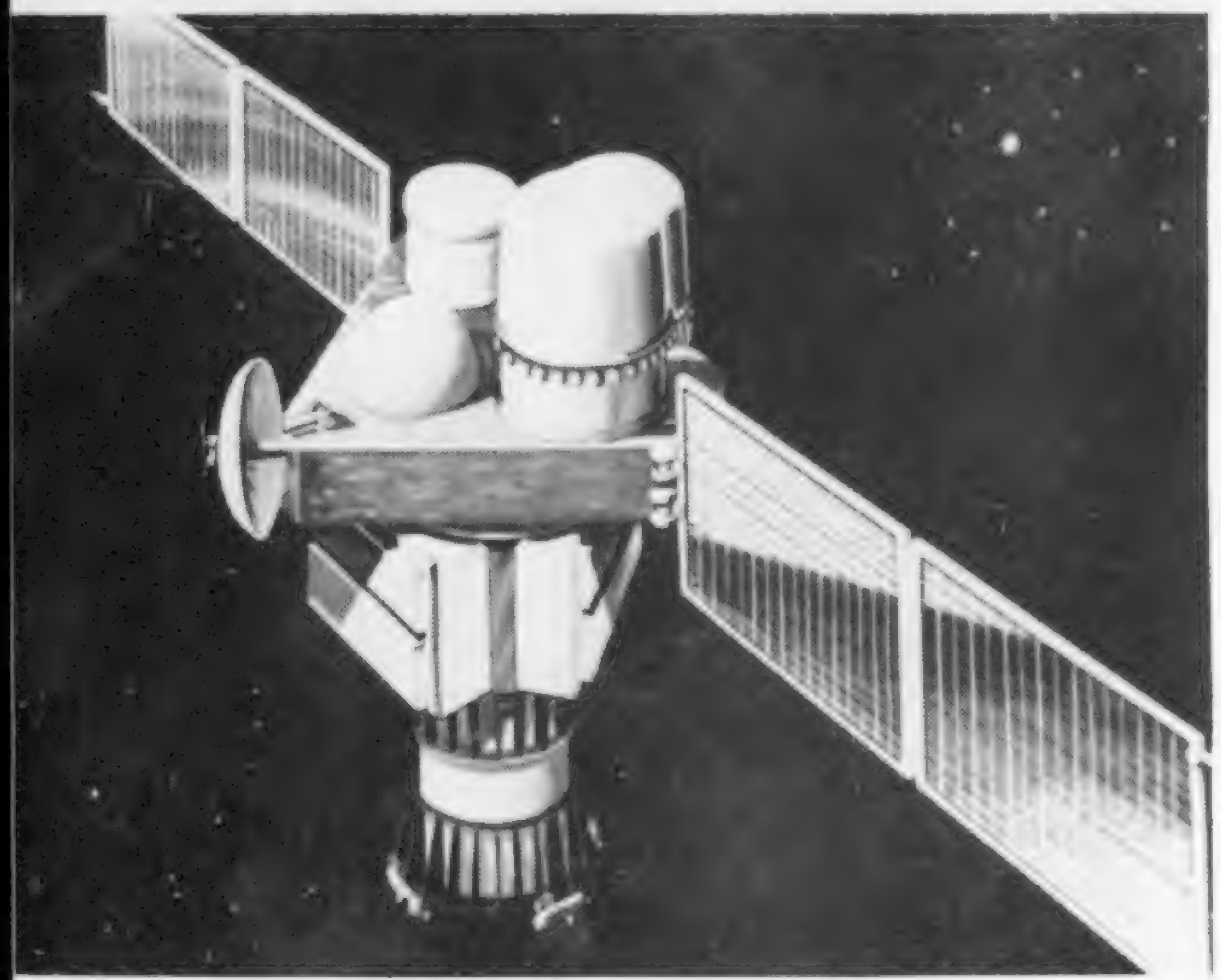

35 800 km average
geosynchronous altitude;
communications and
some weather satellites
25 700 km
perigee
(apogee
45 850 km)
IUE
International
Ultraviolet
Explorer
20 372 km
Navstar
navigation
satellites
5900 km
LAGEOS
(Laser geodynamic
satellite)
1520 km
NOAA-5 (polar
orbit, weather)
LANDSAT 3
OSCAR 8
900 km
300 km
Shuttle
parking
orbit

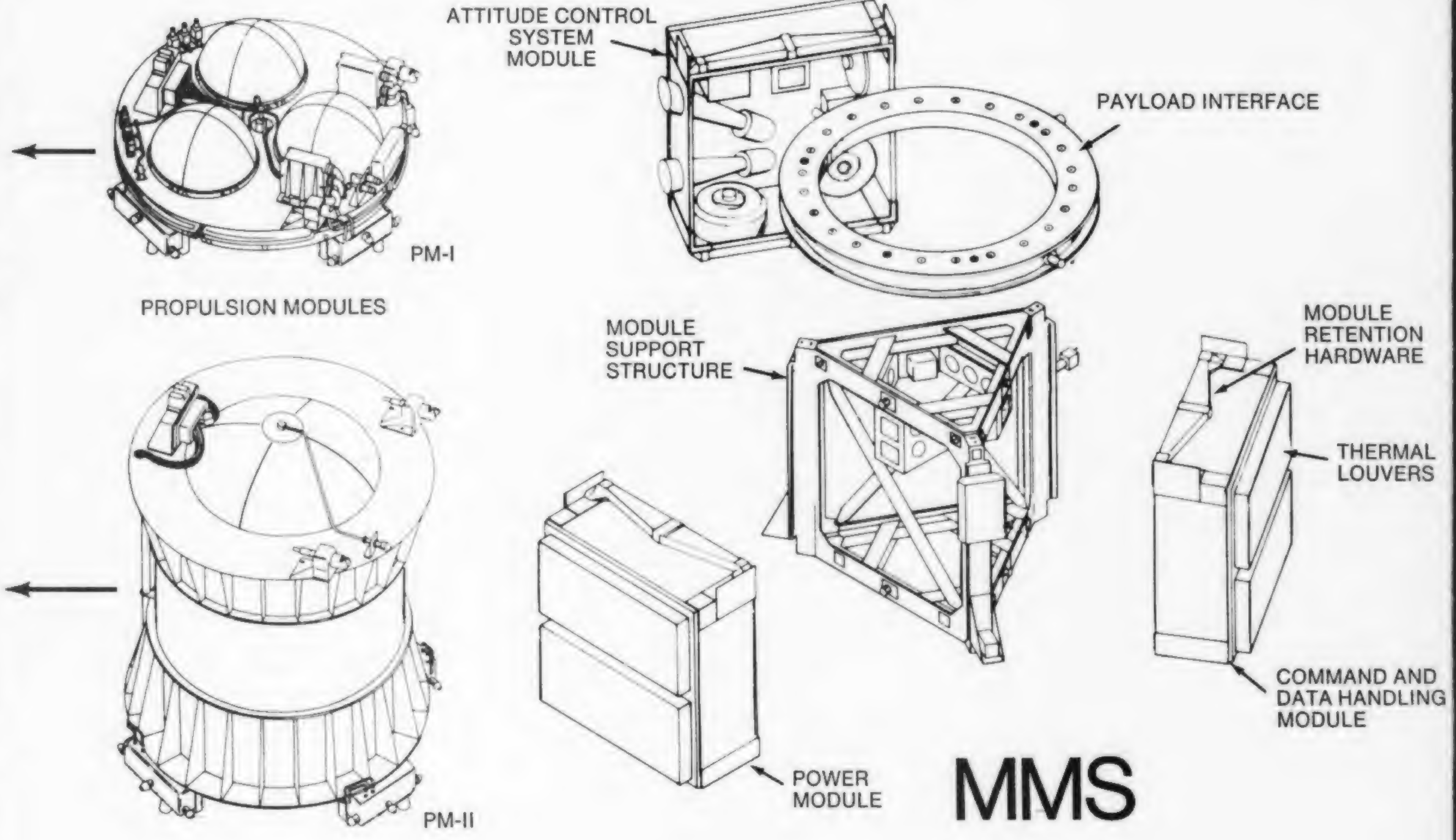
Continued from Preceding Page

2. Multimission Modular Spacecraft

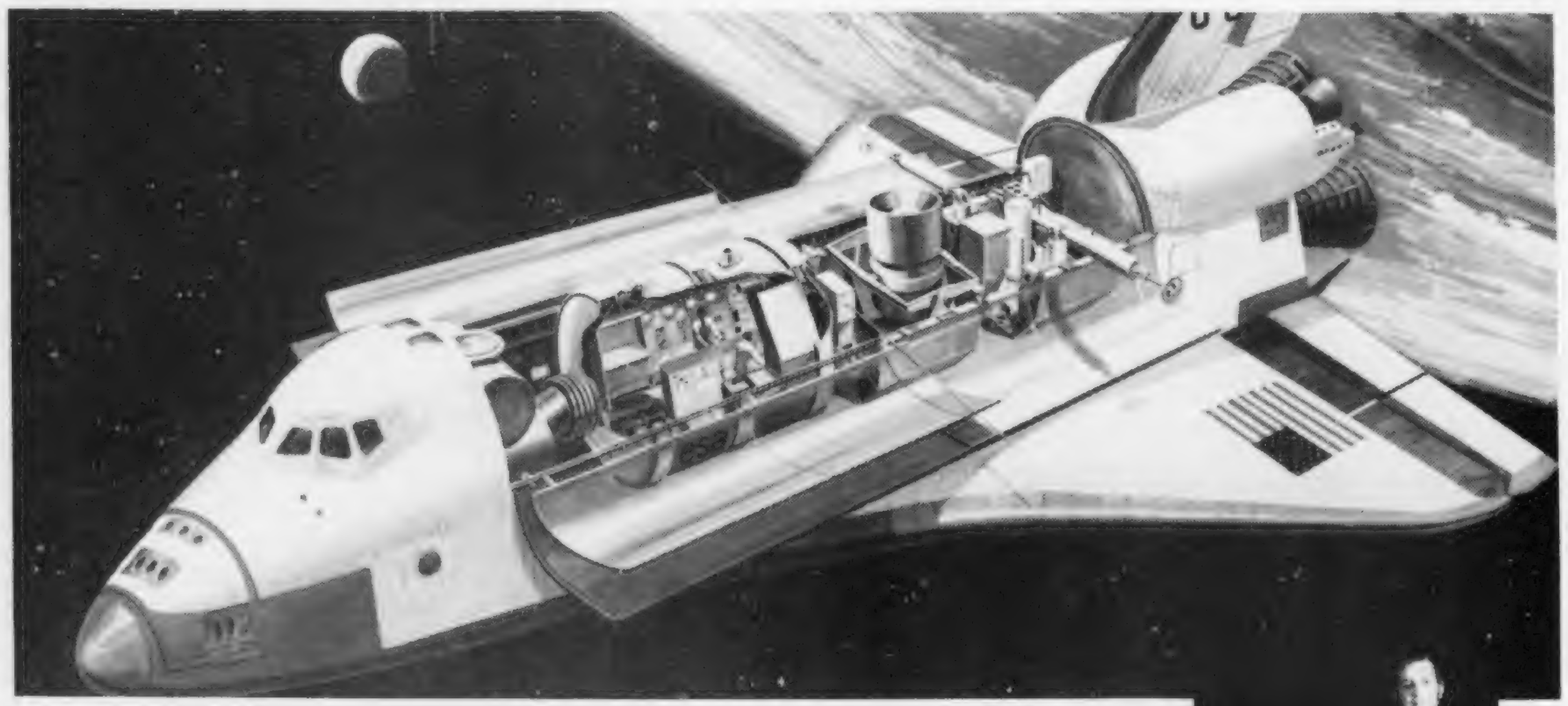
The MMS was born of NASA's effort to reduce costs by re-using existing spacecraft for different kinds of missions; previous structures did not adapt well, even though many functions are common to practically all missions. The MMS core is a triangular module support structure. Standardized units are hung on the sides: (1) a power source (batteries, with optional choices); (2) attitude controls (with changeable programming from the ground); and (3) a versatile command and data handling module. The mission instrument package is fixed to the ring, on top. Other equipment can be attached below, on the "aft face." The Solar Maximum Mission will carry an antenna. At times, a propulsion module (PM) will be needed. PM-I holds 76 kilograms of hydrazine propellant, and is one of several means for keeping a satellite steady in its orbit and pointed properly. Its first use will be with Landsat D (artist's drawing, top left). The PM-II concept with 481 kg of hydrazine, could not only kick a spacecraft higher than Shuttle's parking orbit, but also bring it back down for servicing or retrieval. It would suit a mission like the Gamma Ray Observatory (art, lower left). According to Robert E. Davis, MMS liaison manager at Goddard Space Flight Center, MMS standardizations will make it easier for Shuttle crew members to update, repair or replace any part of the MMS while on orbit.



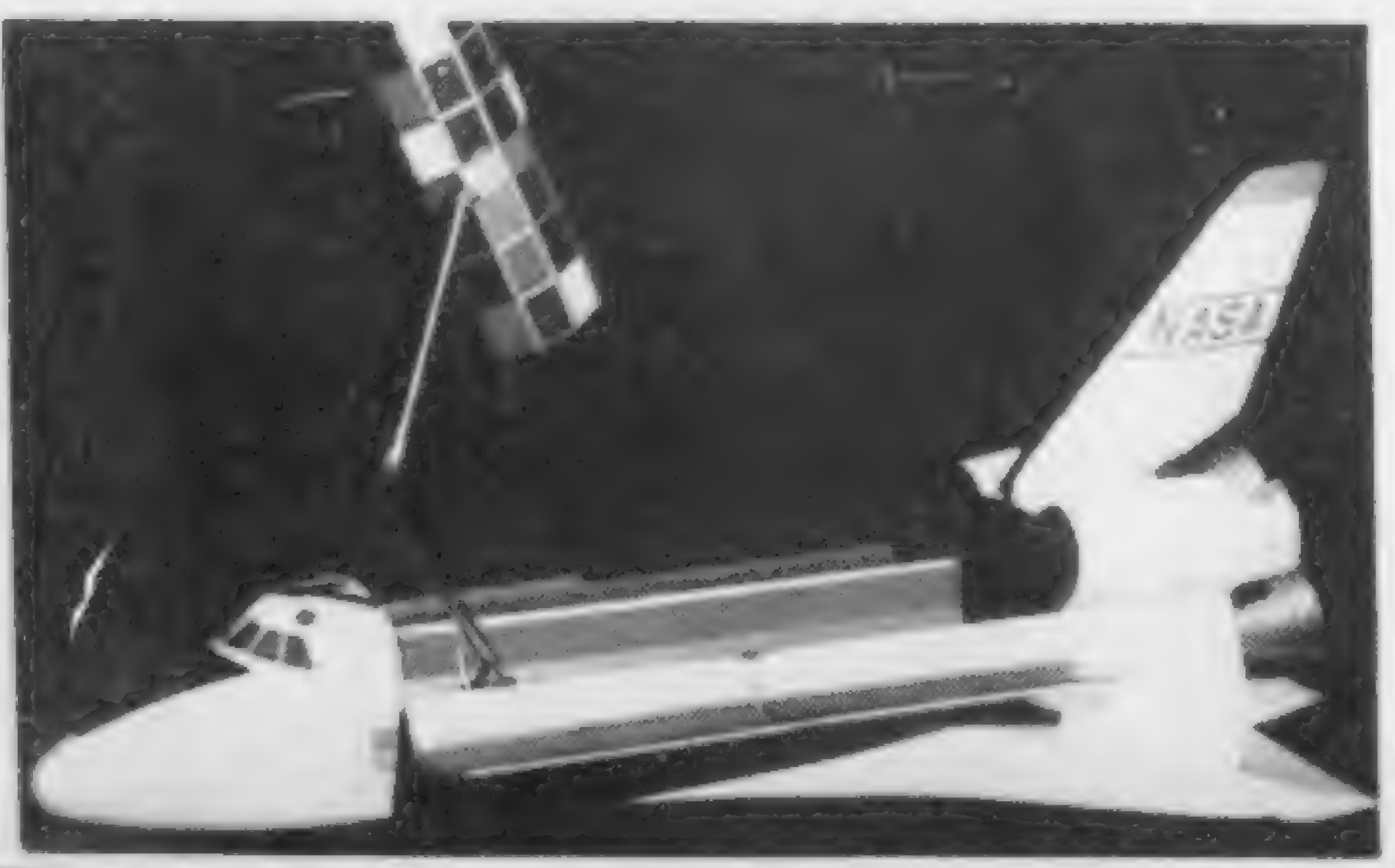




Many payloads will do their work at Shuttle's parking orbit



At 300 km, orbiters are exposed to virtual vacuum and microgravity. Scientific and industrial experiments will be made while the orbiter circles Earth, usually for a week per trip. Various orientations toward Earth or space can be arranged; see *Air & Space*, January 1979, Pg. 6. Substantial equipment can fly in Spacelab, built by the European Space Agency to fit orbiters. Small, self-contained experiments, "Getaway Specials," are stowed on board wherever possible. The Long Duration Exposure Facility (LDEF) is a 9.1-meter long cylinder holding dozens of trays of experiments to test long-term effects of space on materials. It stays in orbit as long as required, and is then retrieved for return to Earth.



Above, cutaway drawing of Spacelab in one of many configurations of pressurized module laboratories with open pallets. Left, unloading LDEF.

Left, a cannister for "Getaway Specials"

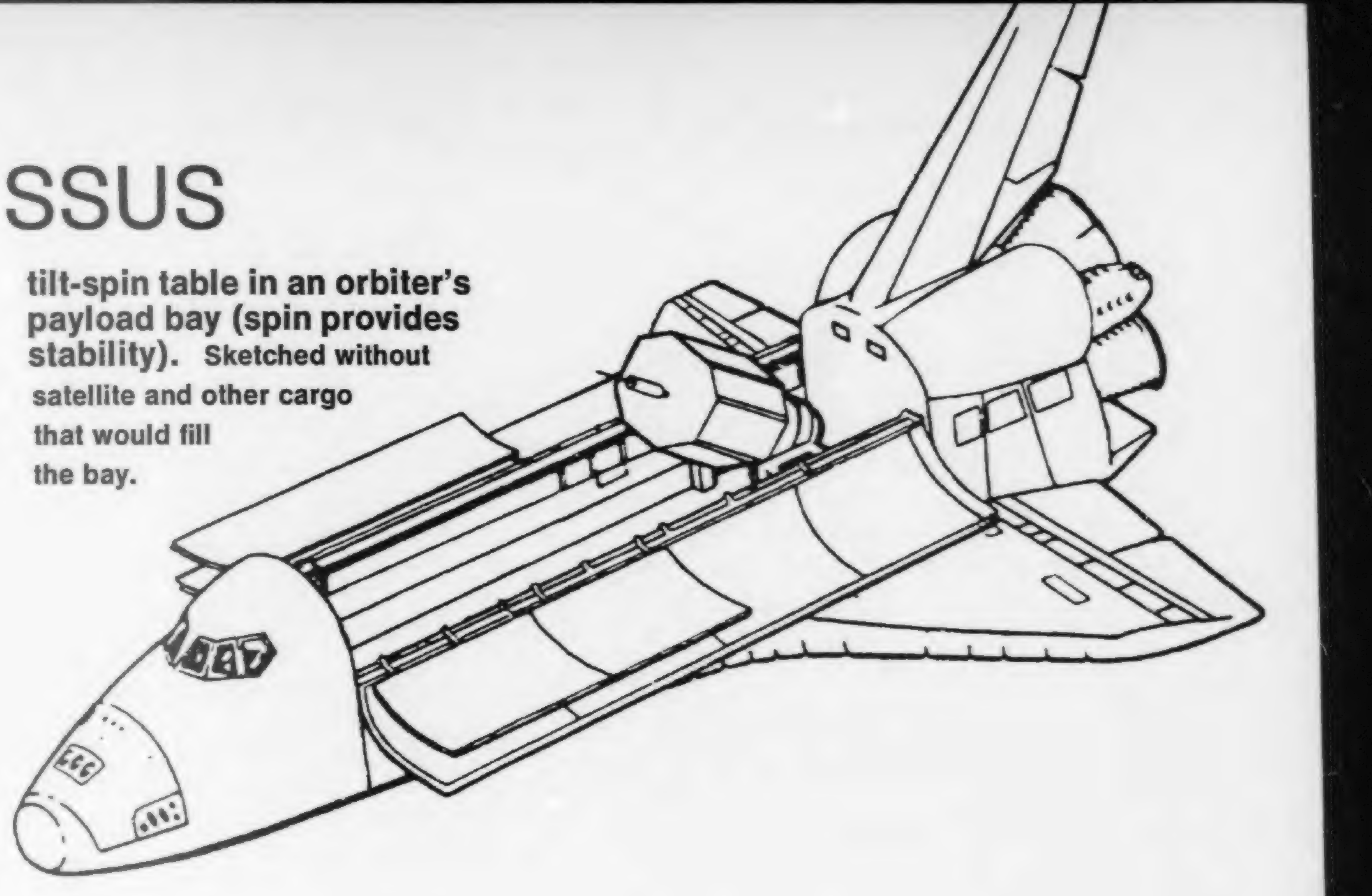
3. Spinning Solid Upper Stage

SSUS is NASA's acronym for comparatively simple, low cost, single stage, solid propellant boosters which work very much like the familiar third stage of the Delta expendable launch vehicle. One version, SSUS-D, can be used either atop a Delta or aboard Shuttle. After an orbiter establishes an aim point, the SSUS (with satellite) is spun up and spring-released. The spin maintains stability throughout the trajectory which usually will establish an elliptical transfer orbit with apogee at the geosynchronous level. Up there, the burned-out SSUS motor is jettisoned. Small thrusters on the satellite itself can then work the unit into the final geosynchronous circular orbit. SSUS was developed by McDonnell Douglas Astronautics as a commercial product available to any customer.

McDonnell Douglas calls the SSUS a Payload Assist Module or PAM. PAM-D equals a launch on a Delta which can take approximately 1100 kilograms to geosynchronous transfer orbit. PAM-A equals a launch on an Atlas-Centaur which can lift 2000 kg. This weight distinction is preserved when PAMs are powering satellites in a state of weightlessness because mass is still involved in equations for calculating trajectories.

SSUS

tilt-spin table in an orbiter's payload bay (spin provides stability). Sketched without satellite and other cargo that would fill the bay.



4. Inertial Upper Stage

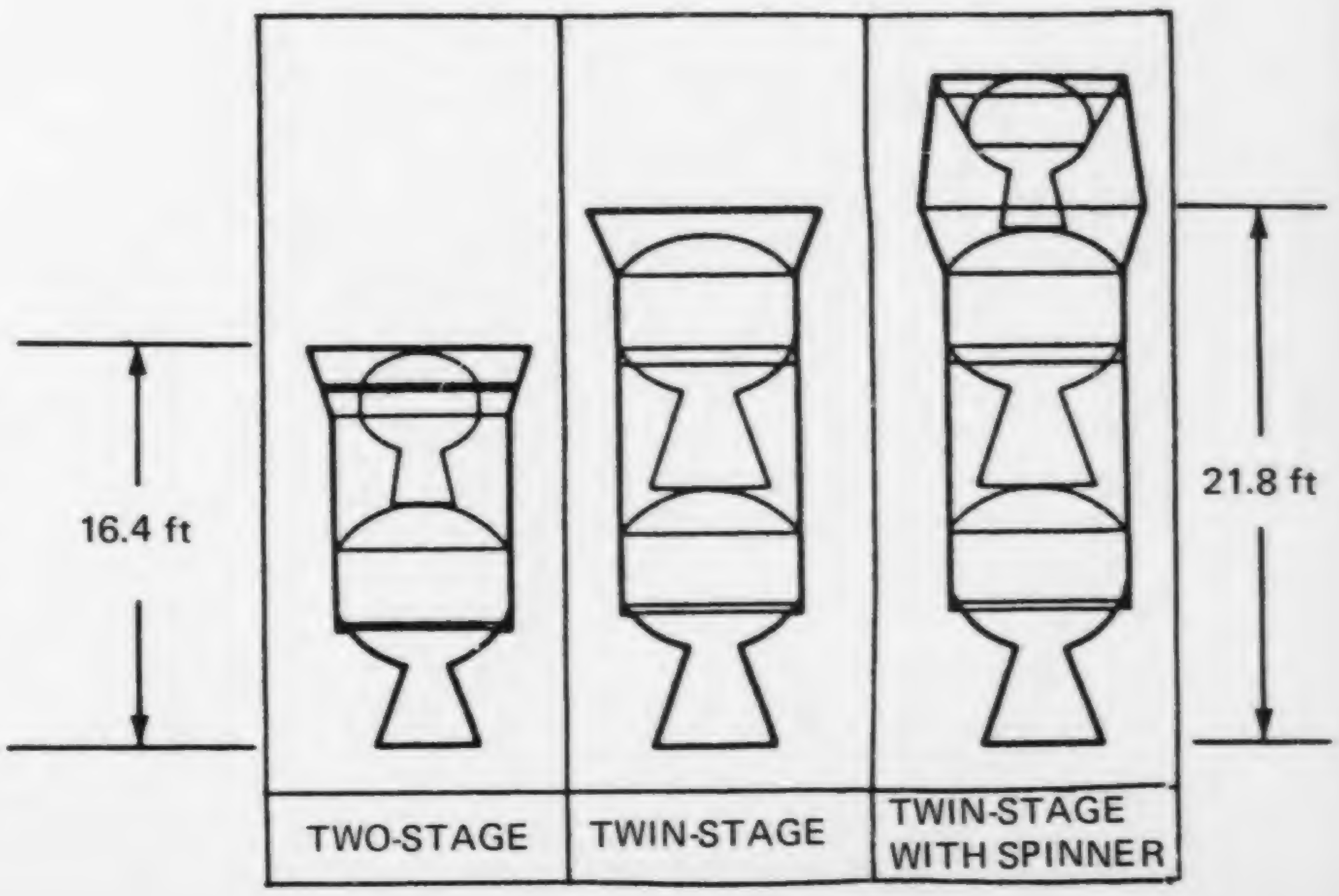
Three combinations of large and small solid propellant motors, outlined to the right, provide a powerful two or three stage thrust beyond Shuttle's level for the heaviest, most complex missions. IUS will work with either Shuttle or the Titan expendable launch vehicle.

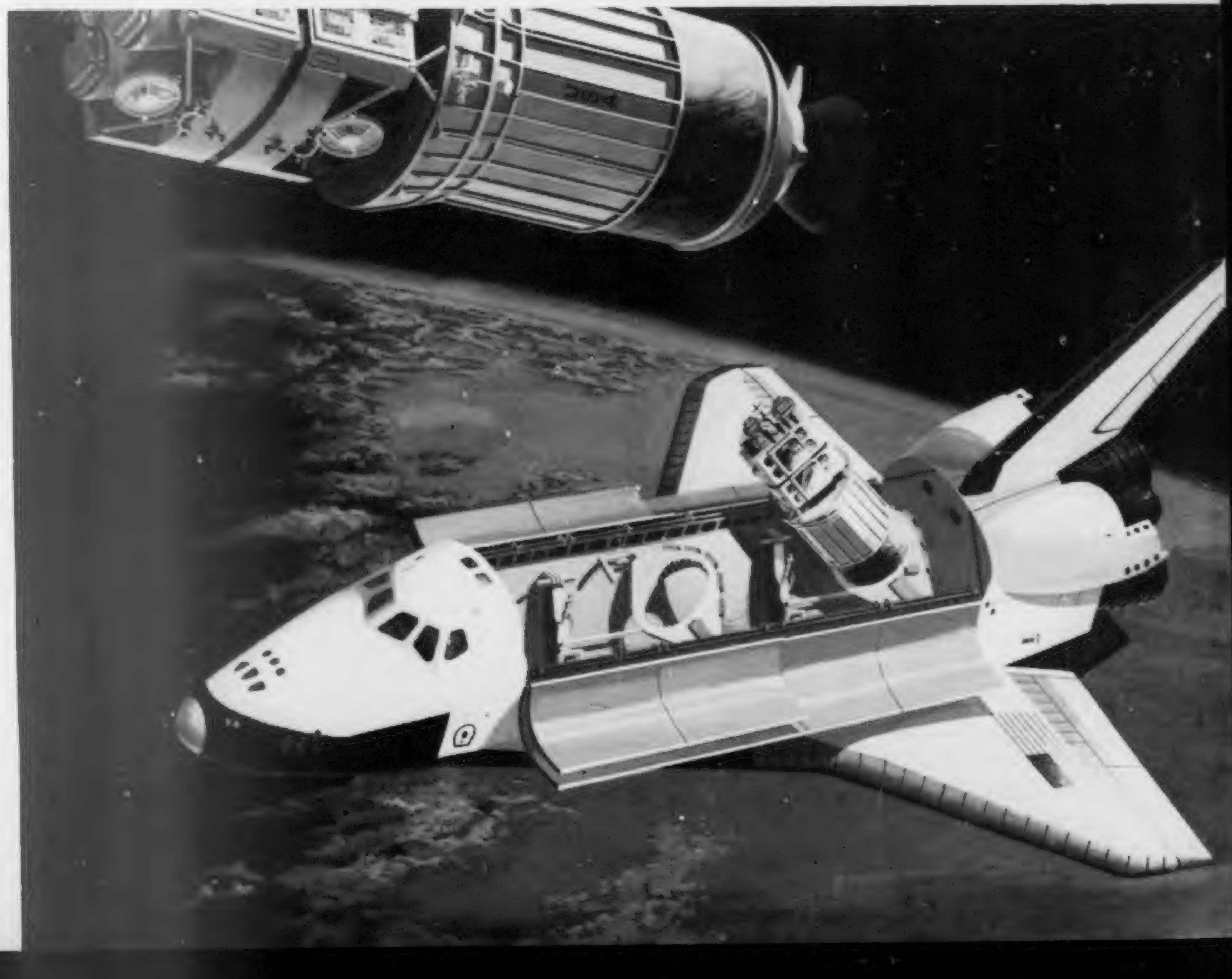
Built by Boeing Aerospace, IUS was government-funded principally by the Air Force, but is available to other customers. Each unit includes redundant provisions for power, guidance, telemetry, tracking, control and other operations. One motor injects the unit into geosynchronous transfer orbit like an SSUS, but the second motor completes the job of working into a circular orbit before the booster is jettisoned. Larger versions of IUS will be used for lunar and interplanetary missions.

MMS, SSUS-PAM and IUS are expected to be used until the mid-1980's, by which time improved upper stages will have been developed.

IUS

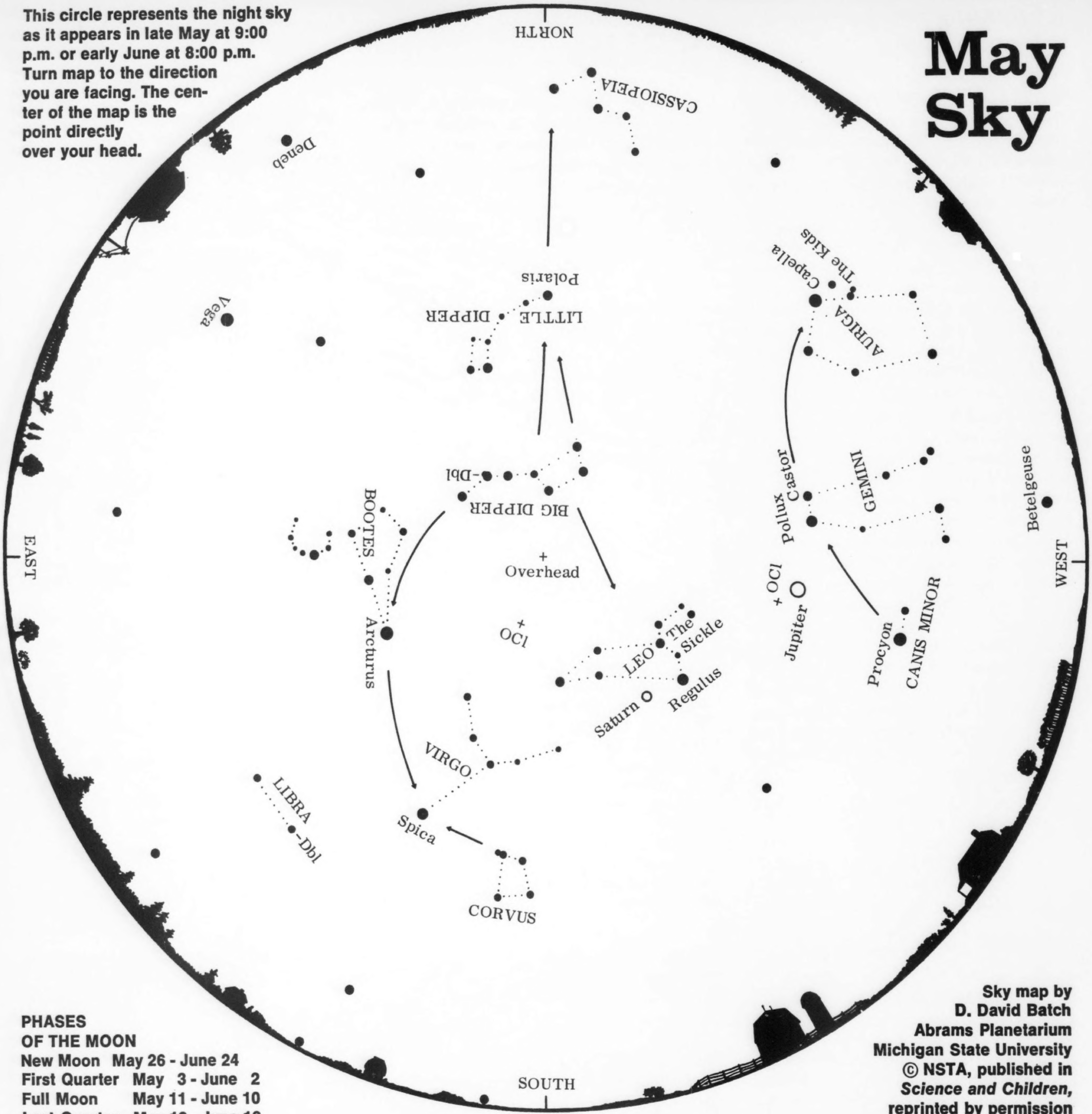
Two comparatively light-weight satellites with smaller IUS motors will be able to share the first stage of their launch aboard an orbiter. In the drawing below, no specific satellite is delineated. Markings on the orbiter vary in sketches made at different times.





May Sky

This circle represents the night sky as it appears in late May at 9:00 p.m. or early June at 8:00 p.m. Turn map to the direction you are facing. The center of the map is the point directly over your head.


NORTH
CASSIOPEIA
Deneb
Polaris
LITTLE DIPPER
Vega
The Kids
Capella
AURIGA
Dbl
BIG DIPPER
BOOTES
Overhead
EAST
WEST
Arcturus
OCl
Pollux
Castor
GEMINI
Betelgeuse
OCl
Jupiter
LEO
The Sickle
Regulus
Saturn
Procyon
CANIS MINOR
VIRGO
LIBRA
Dbl
Spica
CORVUS
SOUTH

PHASES OF THE MOON

New Moon	**May 26 - June 24**
First Quarter	**May 3 - June 2**
Full Moon	**May 11 - June 10**
Last Quarter	**May 18 - June 16**

Sky map by
D. David Batch
Abrams Planetarium
Michigan State University
© NSTA, published in
Science and Children,
reprinted by permission

by T. H. Callen II
Albert Einstein Spacearium, NASM

With spring re-awakening planet Earth, new stars sparkle in the heavens. Spring star groups rise in the east while the last stars of winter linger low in the west; by midnight, all have set. Later in the night, summer stars replace those of spring, which move higher up.

Just after sunset in mid-May the bright, reddish star Betelgeuse in Orion, the Hunter, is very low in the west, setting about two hours later. Higher in the west the Gemini twins and the pentagon of Auriga, the Charioteer, await their turn to set about five hours after sunset. Jupiter is easily seen as a bright object to the left of Gemini in the faint constellation of Cancer, the Crab. Last March, Voyager 1 sped by this giant of the Solar System and sent back scientific data and spectacular views (see back cover). In July, Voyager 2 will pass on a different course and also return information.

Directly below the Big Dipper is Leo, the Lion. The head and mane of Leo resemble a harvester's sickle or a backwards question mark. The period of the "question mark" is the bright star Regulus. Saturn, fainter than Jupiter, is to the left of this star, so that it appears under the lion's belly.

The curved handle of the Big Dipper can help us to find two other prominent spring stars. The handle forms an arc; "Follow the arc to Arcturus . . ." Arcturus is an orange star at the base of Bootes, the Herdsman. Now, ". . . speed on to Spica." Spica is the blue-white star in Virgo, the Virgin. She is holding a shock of wheat in one hand with Spica marking one grain.

Vega and Deneb, the first bright stars of summer, are seen low in the northeast a few hours after sunset. By midnight they are high up in the east.

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TO PRESENT REGISTRANTS

Registration is permanent (until some future check). Please DO NOT reregister for 1979-1980.

AEROSPACE WORKSHOPS

Quantities of *Air & Space* may be available for each teacher attending aerospace education workshops this summer; send request to Room 3569.

In view of resource limitations, new registrations for Air & Space will be suspended as of May 30, 1979.

Good Reading

United States Women in Aviation Through World War I, Claudia M. Oakes (Assistant Curator, Aeronautics, NASM). 44 pp., rare illus. Smithsonian Press, P.O. Box 1641, Washington, DC 20013, 1978, $2.50.

Space Trek, Jerome C. Glenn and George S. Robinson (Smithsonian's Assistant General Counsel). 223 pp., illus., biblio., index. Stackpole Books, Harrisburg, PA 17105, 1978, $9.95.

Shuttle into Space, G. Harry Stine. Paperback, 127 pp., illus., glossary, list of Space Shuttle jobs, index. For ages 10-18, narrative of a flight. Follett, Chicago, IL 1978, $4.95.

Space Shuttle, Marshall H. Kaplan. 215 pp., illus., diagrams, glossary, index. By an aerospace engineering professor. Aero Publishers, Fallbrook, CA 92028, 1978, $14.95.

ILLUSTRATION CREDITS

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THINK ALONG WITH PLANETARY SCIENTISTS

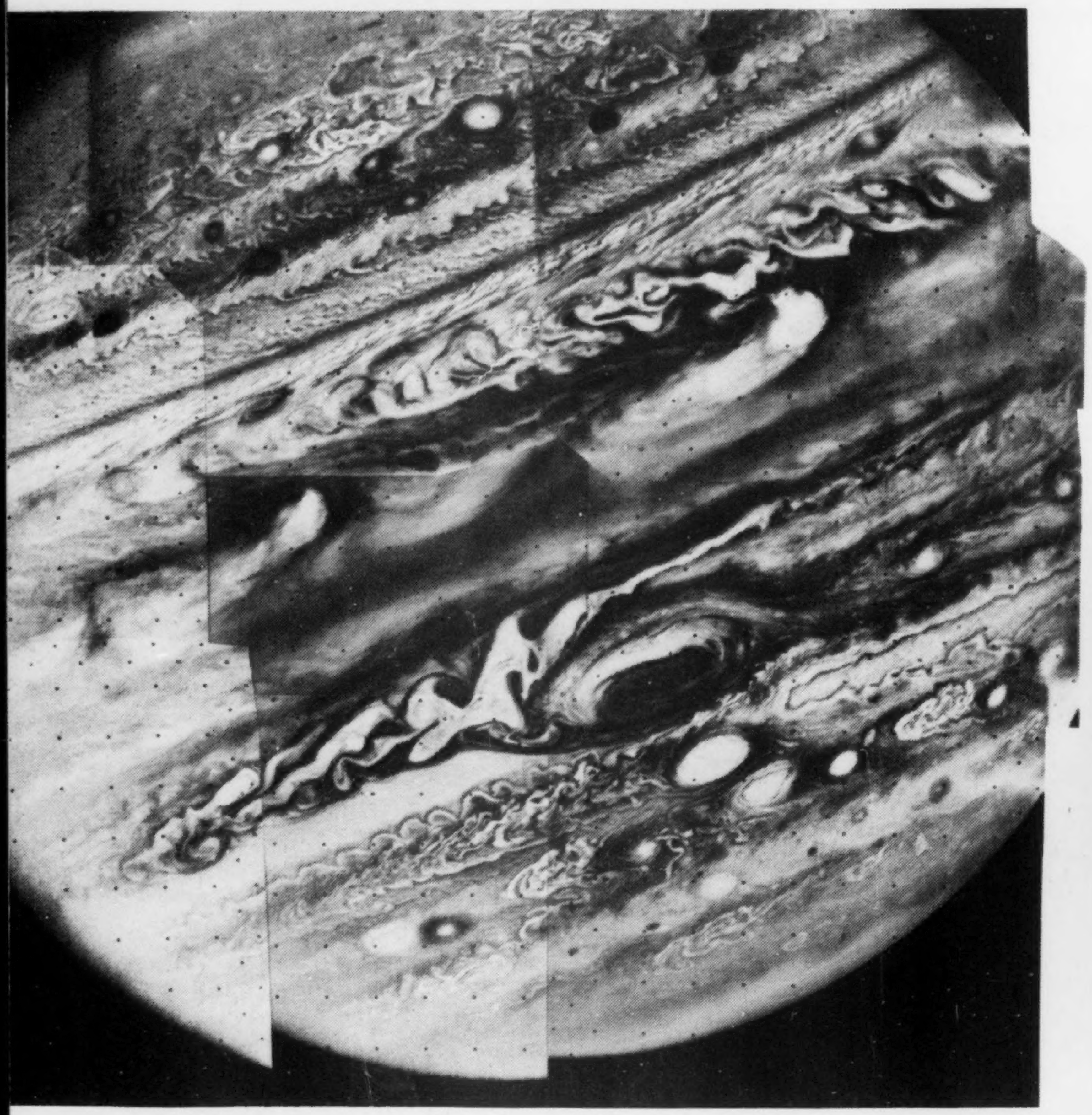
about Jupiter, as seen by Voyager 1

New questions kept scientists agog at Jet Propulsion Laboratory when data was flowing in from Voyager 1 at Jupiter last March. Voyager sped through the fierce radiation at 104 500 kilometers per hour, 279 000 km from the cloudtops, sending images much sharper than those from Pioneer 11 (December, 1974).

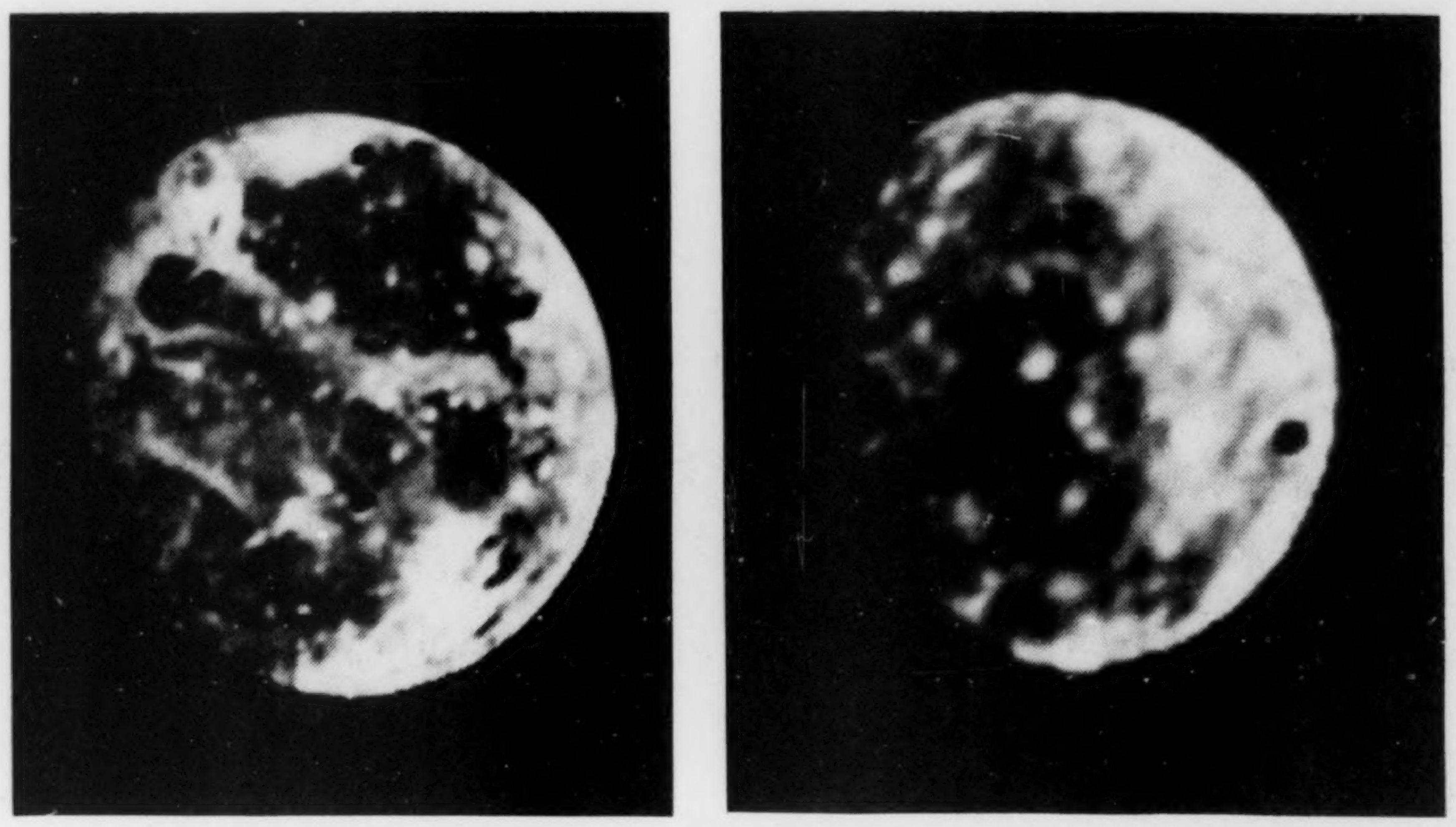
What's in the newly found ring? "Thunderheads" in the hydrogen-helium atmosphere now seem to be something else; what is the convective mechanism? The Great Red Spot may be a passive storm, a permanent eddy 13 000 km wide, 30 000 km or more long. Is it maintained by its bordering jetstreams of different speeds in opposite directions?

The first closeups of the big moons show startling color. What is the chemistry of the orange, brown, mustard, yellow, white and tan? Ganymede and Callisto are believed to be ice balls, half water, half rock. Ganymede has surface faults which look like a process of plate tectonics; geologists had thought that Earth was the only globe with moving crusts. On Io, volcanoes continually belch ash and gas; lava overflows and smooths the surface. Io is the most geologically active body known in the Solar System. Are the "pizza colors" and the sulfur torous (doughnut-shaped cloud) glowing at 100 000°C the result of surfur compounds ejected by the volcanoes? Voyager 2 will send more data in July. Then both craft are starting their two-year trip to Saturn. Pioneer 11 (Pioneer Saturn) will reach the ringed planet next September.

The moon Io against the disk of Jupiter.



The two largest of 13 known moons, each larger than Mercury.



GANYMEDE **CALLISTO**

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